PB-229 204

SAVANNAH RIVER STUDIES, 1955

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1 June 1957

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 229 204

INTERIM REPORT

ON THE

SAVANNAH RIVER STUDIES

1955

Prepared by

Water Pollution Control,

Water Supply and Water Pollution Program

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Sanitary Engineering Services
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio
June 1, 1957

TABLE OF CONTENTS

	Page
LIST OF CONTRIBUTORS	i
ACKNOWLEDGMENTS	ii
CHAPTER I	
SUMMARY OF FINDINGS AND RECOMMENDATIONS	1
FINDINGS	1
RECOMMENDATIONS	5
CHAPTER II	
GENERAL INFORMATION	6
OBJECTIVES	6
INITIATION OF STUDIES	6
SAMPLING STATIONS AND PROGRAM	7
LOCATIONS OF SAMPLING STATIONS, LANDINGS AND TRIBUTARIES	8
LABORATORY ACTIVITIES	13
CHAPTER III	
GENERAL DESCRIPTION	14
CHAPTER IV	
STREAM FLOWS	16
DISCHARGE DATA	16
Savannah River at Augusta, Georgia (S-216)	16
Savannah River at Burton's Ferry Bridge (Millhaven) (S-129.25)	17
Savannah River near Clyo, Georgia (S-64.9)	17

Page

STREAM FLOWS AS RELATED TO WATER USES 17

CHAPTER V

CHEMICAL, PHYSICAL, AND BACTERIOLOGICAL STUDIES 25

CHEMICAL AND PHYSICAL EXAMINATIONS 26

Temperature 26

Turbidity 27

Color 27

Alkalinity and Chlorides 28

Hydrogen Ion Concentration (pH) 28

Dissolved Oxygen 32

Biochemical Oxygen Demand (B.O.D.) 37

Iron and Manganese 37

Mineral Analyses 38

Suspended Load 43

BACTERIOLOGICAL EXAMINATIONS 43

SPECIAL DATA RELATING TO WATER QUALITY 44

Clark Hill Reservoir Water Quality Studies 44

Water Treatment Plant Water Quality Data 49

Augusta, Georgia, Water Filtration Plant 49

North Augusta, South Carolina, Water Filtration Plant 49

CHAPTER VI

BIOLOGICAL STUDIES 50

BIOLOGICAL COLLECTIONS RELATED TO BIOTIC HEALTH 51

RELATIONSHIP OF PLANKTON TO WATER TREATMENT INSTALLATIONS 54

FISHING AND RECREATION 55

Page

CHAPTER VII

BACKGROUND RADIOACTIVITY OF WATER, BIOTA, AND MUD 57

RADIOACTIVITY OF WATER 57

RADIOACTIVITY OF BIOTA 59

RADIOACTIVITY OF MUD 61

CHAPTER VIII

BIBLIOGRAPHY OF REPORTS ON THE SAVANNAH RIVER 65

DIATOMETER REPORTS 65

GENERAL SURVEY REPORTS 66

REPORTS RELATING TO FISH AND ALGAE 67

APPENDICES

APPENDIX "A"

SUMMARY OF INDIVIDUAL RESULTS-SANITARY EXAMINATIONS 69

S-230.7 71

S-218 72

S-203 73

S-197 74

S-172 75

S-152 76

S-28, Ab-2.5 - Abercorn Creek - (Savannah W.P. Intake) 77

S-23 78

S-14 79

S-11 80

S-5 81

Page

APPENDIX "B"

SUMMARY OF IRON AND MANGANESE RESULTS, and U. S. GEOLOGICAL SURVEY MINERAL ANALYSES 83

APPENDIX "C"

CLARK HILL RESERVOIR

SUMMARY OF INDIVIDUAL RESULTS OF WATER QUALITY 87

APPENDIX "D"

MONTHLY MEAN DISCHARGE DATA from U. S. GEOLOGICAL SURVEY 91

APPENDIX "E"

DESCRIPTION OF THE PROCEDURES USED FOR ASSAYING THE RADIOACTIVITY IN FRESH WATER, BIOTA, AND MUD 97

RADIOACTIVITY OF WATER 97

Suspended Solids 97

Dissolved Solids 97

Special 98

RADIOACTIVITY OF BIOLOGICAL SAMPLES 98

Fish Samples 98

Algal Samples 99

RADIOACTIVITY OF MUD 99

COUNTING PROCEDURE 99

Alpha Activity 99

Beta Activity 99

LIST OF TABLES

Table No.		Page
1.	Mean Alkalinity and Chloride Values	31
2.	Occurrence of Macroscopic Invertebrates	53
3.	Radioactivity of Savannah River Water Samples	60
4.	Radioactivity of Fresh Water Fish	62
5.	Radioactivity of Filamentous Algae	63
6.	Radioactivity of Bottom Muds	64

LIST OF FIGURES

Figure No.		Page
1.	Map of Savannah River-Sampling Locations, Clark Hill Dam to Mouth	11
2.	Monthly Mean Discharge at Augusta, Georgia, January 1952 through September 1955	21
3.	Yearly Minimum Daily Discharge at Augusta, Georgia	23
4 and 5	Mean Turbidity and Color Values, Comparison of 1951-1952 Data with 1955. Figure 4, Turbidity; Figure 5, Color	29
6.	Median pH Values, Comparison of 1951-1952 Data with 1955	33
7.	Dissolved Oxygen, Comparison of 1951-1952 Data with 1955	35
8.	5-day B.O.D. @ 20°C., Comparison of 1951-1952 Data with 1955	39
9.	Total and Soluble Iron Content, July 7, 1955	41
10.	Coliforms MPN	45
11 and 12	Dissolved Oxygen-Depth Relation. Figure 11 (S-239.1); Figure 12 (S-246)	47

LIST OF CONTRIBUTORS

The Savannah River Studies in 1955 were carried on under the general administrative direction of W. W. Towne, Chief, Water Pollution Control, Water Supply and Water Pollution Program, Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.

Personnel assigned to the field unit were:

D. D. Gold, Sanitary Engineer (R), In Charge

C. N. Shadix, Chemist

M. Stangler, Radiochemist

W. M. Ingram, Biologist

F. F. Fish, Biologist (Region IV)

M. D. Currey, Engineering Aide

J. O. Hightower, Jr., Physical Science Aide

H. M. Smisson, Physical Science Aide

J. B. Wilbanks, Physical Science Aide

Personnel contributing to the studies at the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, were:

E. E. Geldreich, Bacteriologist, Microbiology

L. R. Setter, Acting in Charge, Radiological Investigations

E. C. Tsivoglou, Sr. Sanitary Engineer, Water Pollution Control.

ACKNOWLEDGMENTS

Valuable assistance was rendered by persons from various municipal, industrial, State and federal agencies during these studies. Special acknowledgment is made to the following:

South Carolina State Board of Health

Mr. William T. Linton, Executive Director, Water Pollution Control Authority

City of Augusta, Georgia

Mr. Grady Wyld, Superintendent, Augusta Water Filtration Plant

City of North Augusta, South Carolina

Mr. A. L. Metz, Superintendent, Water Department

Mr. E. S. Limehouse, Chief Operator, North Augusta Water Filtration Plant

Atomic Energy Commission, Savannah River Plant

Mr. G. H. Giboney, Chief, Radiological Control Branch

Mr. Karl Herde

U. S. Corps of Engineers, Savannah River District

Mr. J. W. Harris, Chief, Savannah Harbor Investigation and Study Section

U. S. Geological Survey, Columbia, South Carolina District

Mr. Albert E. Johnson, District Engineer

U. S. Public Health Service

Mr. L. A. Young, Assistant Regional Engineer, Water Supply and Water Pollution Control Activities, Region IV, 50 Seventh Street, N. E., Atlanta 23, Georgia

E. I. DuPont de Nemours and Company

Mr. C. M. Patterson, Superintendent of Health Physics Section, Savannah River Plant

Savannah River Studies Advisory Board members who have participated in data review and planning of the continuing studies of the Savannah River are as follows:

Georgia Department of Public Health

Mr. W. H. Weir, Director, Water Pollution Control, Atlanta, Georgia.

South Carolina State Board of Health

Mr. William T. Linton, Executive Secretary, Water Pollution Control Authority, Columbia 1, South Carolina

E. I. DuPont de Nemours and Company

Dr. J. E. Cole, Director, Manufacturing Division, Wilmington 98, Delaware

Atomic Energy Commission

Mr. Arthur E. Gorman, Sanitary Engineer, Division of Engineering, Washington 25, D. C.

Dr. Paul B. Pearson, Chief, Biology Branch, Division of Biology and Medicine, Washington 25, D. C.

U. S. Corps of Engineers

Mr. Harry Sugden, Chief, Planning, Reporting, Programming and Budgeting Branch, Savannah District, P. O. Box 889, Savannah, Georgia

U. S. Geological Survey

Mr. Albert E. Johnson, District Engineer, 210 Creason Building, Columbia 1, South Carolina

U. S. Public Health Service

Mr. Ralph C. Palange, Assistant Chief, Water Supply and Water

Pollution Control Program, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio

Mr. W. W. Towne, Chief, Water Pollution Control, Water Supply and Water Pollution Control Program, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio

Mr. James G. Terrill, Jr., Chief, Radiological Health Branch, Washington 25, D. C.

Mr. L. F. Warrick, Chief, Technical Services, Water Supply and Water Pollution Control Program, Washington 25, D. C.

Mr. Lewis A. Young, Assistant Regional Engineer, Water Supply and Water Pollution Control Activities, Region IV, 50 Seventh Street, N. E., Atlanta 23, Georgia

CHAPTER I

SUMMARY OF FINDINGS AND RECOMMENDATIONS

This report is based principally on findings from field studies of the Savannah River that were conducted from June 13, 1955, to August 12, 1955. It is supplemental to an earlier Public Health Service report that was based on field studies that were done in 1951-1952.[1] Whenever possible, 1955 data are compared with those of 1951-1952 to record Savannah River conditions that were found to have changed or were similar.

Certain information from other agencies, that supplement data obtained by the Public Health Service, have been incorporated here. Some of these data were collected between 1951-1952 and 1955 when the Service was not active in field investigations of the river. Such are presented for their value in recording certain water quality conditions that have occurred in the interim and are significant to the preparation of this report.

FINDINGS

The findings are as follows:

1. The Savannah River water in the reach from Clark Hill Reservoir to the estuary are of very good quality except for domestic sewage pollution below Augusta, Georgia, and for domestic and industrial pollution at Savannah, Georgia

---

[1] Interim Report on the Savannah River Studies, July 1951-July 1952, U. S. Department of Health, Education, and Welfare, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1954.

2. The hydrological, physical, chemical, and bacteriological characteristics of Savannah River water at Mile S-152, immediately below the Atomic Energy Commission's Savannah River Plant, are generally a fair average for the entire section of river studied, unless otherwise stated in succeeding findings.

3. Stream flows have been stabilized markedly by Clark Hill Reservoir. High stream flows usually occur during the months of February, March, April and May. Low flows tend to occur during the period, June to November. High flows amounting to 37,800 cfs, 35,000 cfs, and 17,600 cfs occurred for the years 1952, 1953, and 1954, respectively. The average flows for these years at Millhaven were 9,300 cfs, 8,600 cfs, and 7,400 cfs, respectively.

4. The river waters have cleared considerably since impoundment of waters in Clark Hill Reservoir which was initiated in 1952. The mean turbidity during the 1955 studies was 16 ppm. The mean turbidity during the 1951-1952 studies was 56 ppm. Turbidity values are higher after heavy rains and are considerably greater (between 100-260 ppm) in the estuarine portion of the river.

5. The only significant change in water temperature of the river, from the pattern that existed in 1951-1952, is a lower temperature in the section from Clark Hill Dam (S-238.1) to the New Savannah Bluff Lock and Dam during the warmer months. This is a result of cold water releases from Clark Hill Reservoir from depths of from 40 to 50 feet. Clark Hill Reservoir water becomes

stratified; 1955 investigations revealed a difference in temperature between surface and bottom of 17°C on August 23.

6. Color averaged about 30 ppm during the 1955 studies as compared to 68 ppm during the 1951-1952 studies. At Mile 23 the color was about the same, 44 ppm, for both the 1955 and 1951-1952 studies.

7. Mean values for alkalinity and chlorides were 18 ppm and 2 ppm respectively. These values are in the same range as those obtained in the 1951-1952 studies.

8. There was but little variation in pH at stations above the estuarine reach of the river. Values showed no significant changes from those obtained during 1951-1952.

9. Dissolved oxygen values were practically the same as those measured at corresponding stations during 1951-1952 except at S-230.7 and S-11 where they were considerably lower. High per cent of saturation values, 95 to 100 per cent, was obtained above Augusta and low per cent of saturation values, below 20 per cent, was common near S-11 in the estuarine reach of river.

10. Lower maximum and mean biochemical oxygen demand (B.O.D.) values were obtained for the 1955 studies compared with the 1951-1952 studies, except in the estuarine portion of the river where the B.O.D. was higher.

11. Iron is increasing compared with earlier years, while manganese is decreasing.

12. Clark Hill Reservoir studies from surface to bottom revealed: that dissolved oxygen is depleted in deep water; that pH values decrease from 7.6 to 6.9; that alkalinity increases from 16 to 20 ppm; that color increases from 7 to 60 ppm; and that turbidity increases from 1 to 25 ppm. Chloride values were variable and followed no pattern.

13. Suspended load concentrations have decreased considerably from below Clark Hill Reservoir (S-230.7) to Clyo (S-64.9) with the initiation of controlled discharge from the reservoir.

14. Coliform bacteria numbers varied considerably in range and with the method of estimation. The average value of the most probable number per 100 ml at Mile 152 was 21,800. The membrane filter technique yielded an average value of 5,200 per 100 ml.

15. As in the earlier survey, the radioactivity study showed no radioactivity hazard in the Savannah River. The beta activity was appreciably higher in magnitude than the alpha activity. Both are well below the maximum allowable concentrations as presently recognized for undetermined alpha and beta emitters. There is no apparent trend towards a higher level of radioactivity downstream than upstream. The levels of activity were at

the lower limits of detection by the methods used. No over-all increase in background from the 1951-1952 survey was detected. Mud samples both upstream and downstream from the Savannah River Plant showed measurable activity in nearly every sample. Five aquatic vegetation samples from S-166 downstream to S-5 showed detectable amounts of alpha activity.

16. No extraordinary unbalance of macro-invertebrate associations, from S-218.5 through S-23, were found that could be attributed to an unbalanced environment, such as might result from severe municipal and/or industrial pollution at the fresh water stations.

17. The presence of certain macro-invertebrates and absence of others indicated degradation of water and channel substrate in the brackish water reach from S-14 through S-11.

18. Available data did not indicate that plankton was causing difficulties at water treatment installations.

19. Recreational fishing has apparently increased from what it was in 1951-1952.

RECOMMENDATIONS

1. Brief sampling of the Savannah River upstream and downstream from the atomic Energy Commission's Savannah River Plant should be continued at four month intervals. Such sampling would enable the Public Health Service to maintain a record of data from studies by an agency other than the Atomic Energy Commission or Operations Management which will be available for informational use by State water pollution control authorities.

CHAPTER II

GENERAL INFORMATION

Every effort was made to plan and conduct the 1955 Savannah River Studies in such a manner as to meet the needs and responsibilities of the States involved, the Atomic Energy Commission, and the Public Health Service. Because the river is vital to the operations of the Atomic Energy Commission's Savannah River Plant, and serves as a source of water supply for Augusta, Georgia, North Augusta, South Carolina, and as a partial source of water supply for Savannah, Georgia, it is important to have knowledge of it and its changing characteristics.

OBJECTIVES

The principal objectives of the studies were as follows:

1. To ascertain the effects the Atomic Energy Commission's Savannah River Plant operations have on the radioactivity and quality of the Savannah River and biota.

2. To obtain information relative to the effects of Clark Hill Reservoir operations on downstream water quality and biota.

3. To acquire knowledge relating to municipal and industrial pollution of the river.

INITIATION OF THE STUDIES

The general planning for the 1955 field studies of the Savannah River was carried out during several meetings with members of the Savannah River

Advisory Board held in Augusta, Georgia, on May 16 and 17, 1955. It was deemed advisable that the Public Health Service conduct a brief reconnaissance of the river to obtain minimal data that could be used to compare with those of the 1951-1952 studies.*/ Since the earlier studies, Clark Hill Reservoir has functioned seasonally in controlling upstream flows in the river, the Atomic Energy Commission's Savannah River Plant has been in full operation, and there has been both municipal and industrial expansion in the drainage basin.

SAMPLING STATIONS AND PROGRAM

Samples were collected for radiological, chemical, physical, bacteriological, and biological analysis from a few selected stations from which samples were gathered for similar analysis during the 1951-1952 field studies (Figure 1).*/ These stations were thirteen in number. They were selected as the ones from which most pertinent information would be forthcoming, from a brief survey, to determine the effects on the river of the Savannah River Plant, of Clark Hill Reservoir, and of municipal and industrial pollution. The sampling stations of the 1955 field studies extended from ones in Clark Hill Reservoir, S-246 and S-239.1, to the farthest downstream station at S-5, in estuarine water below Savannah, Georgia. It was not possible to collect as extensive field data as were gathered in 1951-1952 because of the limited time that was allotted for the field studies.

The list of sampling stations, landings, tributaries, etc., is included here from the 1951-1952 report*/ with the principal 1955 stations marked with an asterisk.

*/ See footnote 1, page 1.

LOCATIONS OF SAMPLING STATIONS, LANDINGS, TRIBUTARIES, ETC.

River Mile	Description of Station, Confluence, Etc.
* S-246	Sample Station in Clark Hill Reservoir, 8 miles above Dam
* S-239.1	Sample Station at confluence of Little River with Savannah River
S-238.1	Clark Hill Dam
* S-230.7	Woodlawn Landing (Railroad Bridge), S. C.
* S-218.5	Sample Station just above Rae's Creek, Ga.
S-217.8	Sibley Mill Gate, Ga.
S-217.6	King Mill Gate, Ga.
S-217.2	Hawks Gully Gate, Ga.
S-216.5	North Augusta
S-216.0	Augusta
S-215.79	Southern Railway Bridge
S-215.64	Fifth Street Bridge (USGS Alternate Gage)
S-215.6	Fifth Street Landing, Ga.
S-213.36	Horse Creek, S. C.
S-212.0	Sample Station 1/4 mile above Sand Bar Ferry Road Bridge
S-211.73	Sand Bar Ferry Road Bridge
S-211.38	C & WC Railway Bridge
* S-202.97	New Savannah Bluff Lock and Dam
S-202.9	Sample Station just below New Savannah Bluff Lock and Dam
S-202.65	Butler Creek, Ga. (USGS Augusta Gage)
S-201.65	1 mile below Butler Creek
S-198.95	Thomas Creek, Ga.
S-198.42	Spirit Creek, Ga.
* S-197.0	Sample Station
S-191.8	Hollow Creek, S. C.
S-189.4	Silver Bluff Landing, S. C. (Good landing and access road)
S-186.57	Bridge Creek, Ga.
S-178.57	McBean Creek, Ga.
S-176.66	Boggy Gut Creek, Ga.
S-176.4	Shell Bluff Landing, Ga.
* S-172.0	Sample Station
S-171.59	Upper Three Runs, S. C.
S-165.55	Hancock Landing, Ga. (Good landing with boom & winch, access rd.)
S-164.26	Fourmile Branch, S. C.
S-161.98	Jobblers Creek, Ga.
S-157.3	Brighams Landing, Ga. (Good landing and access road)
S-155.2	Steel Creek, S. C.
* S-152.0	Sample Station
S-146.4	Entrance to Dead River (Little Hell Landing), S. C.
S-145.38	Sweetwater Creek, Ga.

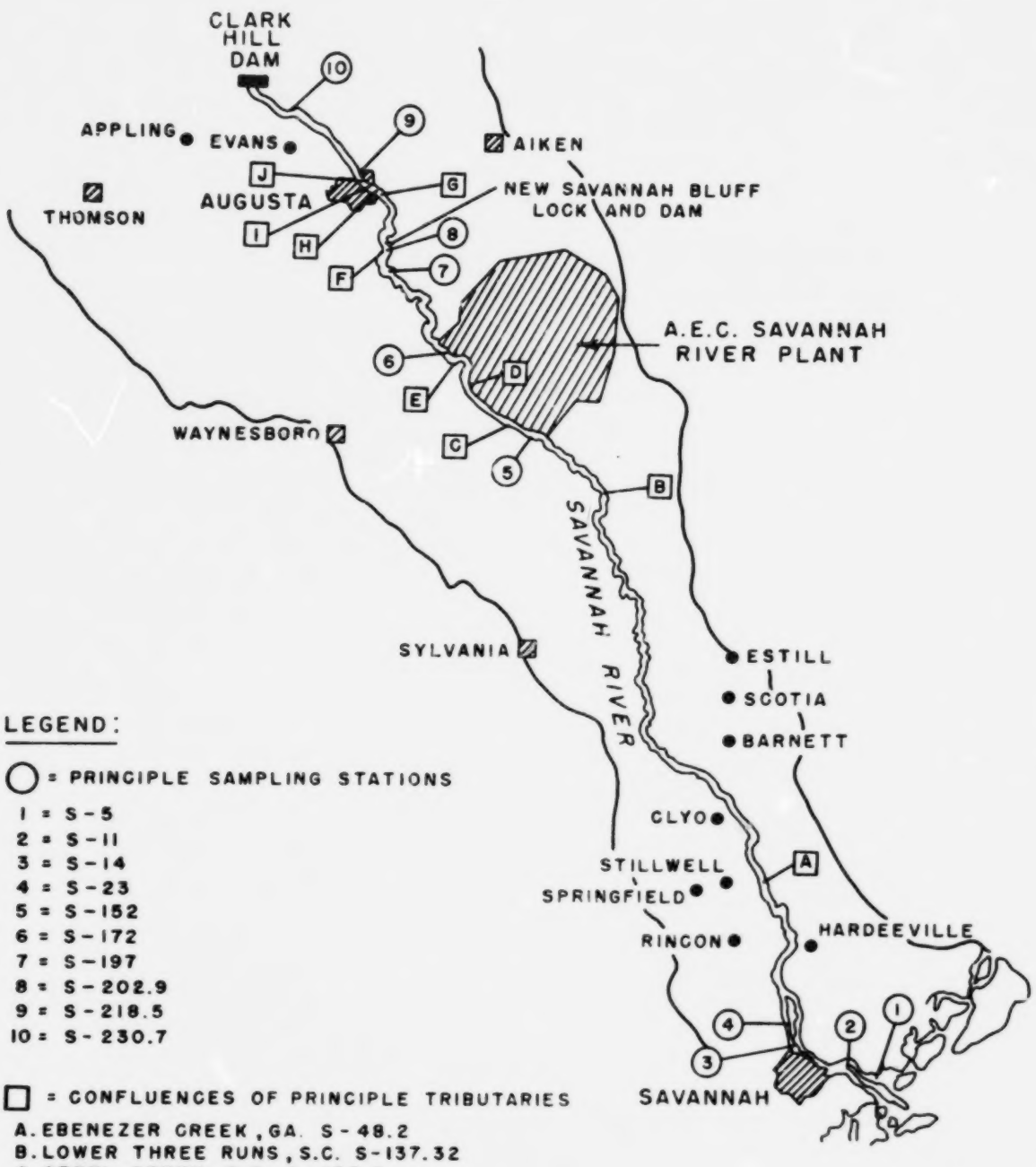
*/ Principal 1955 field studies stations; stations without asterisk represent those where some sampling was done in the 1951-1952 studies.

LOCATIONS OF SAMPLING STATIONS, LANDINGS, TRIBUTARIES, ETC.
(Continued)

River Mile	Description of Station, Confluence, etc.
S-144.65	Stony Bluff Landing, Ga. (Good landing and access road)
S-137.32	Lower Three Runs, S. C.
S-131.27	Rocky Creek, Ga.
S-129.25	Highway 301 Bridge (Burton's Ferry Bridge, USGS Gage)
S-128.23	Briar Creek, S. C.
S-124.76	Swift Creek, Ga.
S-113.7	Cohens Bluff Landing, S. C.
S-106.8	Swift Creek, Ga.
S-105.5	Briar Creek and Landing, Ga.
S-98.93	Buck Creek, Ga.
S-91.7	Poor Robin Landing, Ga.
S-82.53	Black Creek, Ga.
S-82.19	Blue Springs Creek, Ga.
S-81.2	Hudsons Ferry, Ga.
S-68.0	Bostick and Stokes Landing, S. C.
S-64.9888	S.A.L. Railway Bridge (USGS Clyo Gage)
S-52.0	Sample Station
S-48.2	Ebenezer Creek, Ga.
S-48.1	Ebenezer Landing, Ga.
S-46.33	Lockner Creek, Ga.
S-44.74	Mill Creek, Ga.
S-43.24	Big Collis Creek, Ga.
S-42.4	Bear Creek, Ga.
S-36.2	Purysburg, S. C.
S-29.83	Big Collis Creek, Ga.
S-27.36	A.C.L. Railway Bridge
* S-23	Sample Station
S-22.0	Highway Bridge Landing (Hy. 17); Wild Life Landing on Back River, S. C.
S-16.5	Seaboard RR Bridge
S-14.5	Foot of Bull St., Ga. (Corps of Engineers Dock and Laboratory)
* S-14	Sample Station
* S-11.0	Sample Station 1/4 mile below Fort Jackson
* S-5	Sample Station
S-0.5	Old Quarantine Station, Cockspur Island
S-0.0	Vicinity of Fort Pulaski
* S-28,Ab-2.5	Savannah Water Plant Intake on Abercorn Creek

*/ See footnote, page 8

Preceding page blank



SAVANNAH RIVER

CLARK HILL DAM TO MOUTH

FIGURE 1

LABORATORY ACTIVITIES

Most of the analytical work was done in a Public Health Service mobile laboratory between June 13, 1955, and August 12, 1955. The laboratory was located on the grounds of the Oliver General Hospital at Augusta, Georgia, during the early part of the studies, and during the latter part at a public dock at Bull Street, Savannah, Georgia.

Certain samples were analyzed for radioactivity at the Health Physics Laboratory of the Savannah River Plant, while others were sent to the Robert A. Taft Sanitary Engineering Center for similar analysis. Some bacteriological and biological analyses of samples were also done at the latter installation.

CHAPTER III

GENERAL DESCRIPTION

A general description of the Savannah River Basin is contained in the 1951-1952 Public Health Service Report, including topography and geology, population, and water uses and development.*/ Information contained therein is not repeated here for reasons of report brevity.

With more stable river discharge resulting from regulation by Clark Hill Reservoir, shipping, during 1955, has doubled compared with recent years. More freight is being moved on the river now than at any time since the Civil War. When the Hartwell Reservoir project is completed river conditions will offer even more enducement for shipping, with a channel increase in depth of a foot.

The Clark Hill and Hartwell Reservoirs should further the development of industrial sites, especially in providing increased power and stable water discharges.

Recently, mining for titanium has been initiated by Marine Minerals Inc. This operation is situated on Horse Creek, one mile above its confluence with the Savannah River at Mile S-213.36 in Aiken County, South Carolina. Some 175 tons of titanium are mined daily in addition to 1800 tons of gravel.

---

*/ See footnote 1, page 1.

The American Cyanamid Company at Savannah, Georgia, has begun operations in producing titanium oxide, and is discharging wastes to the Savannah River at Mile S-10.

At Savannah, Georgia, the Southern Paperboard Corporation at Mile S-21 and the Union Bag and Paper Corporation at Mile S-17 continue to discharge industrial wastes to the river.

CHAPTER IV

STREAM FLOWS

Information on stream flows contained in this report were obtained from the U.S. Geological Survey.

DISCHARGE DATA

Monthly mean discharges from January 1952 through September 1955 for the Savannah River at Augusta (S-216) Burton's Ferry Bridge (Millhaven) (S-129.25) and near Clyo (S-64.9) are presented in Appendix "D."

Maximum discharges usually occur in February, March, April and May. Minimum daily discharges usually occur during the months of September and October.

Flows in the Savannah River were greatly stabilized with the closure of Clark Hill Reservoir (S-238.1) on December 20, 1951. Today, the average frequency of floods to be expected is once in fourteen years instead of an average of four times a year, which was the expectancy before Clark Hill Reservoir was constructed. Prior to construction of this reservoir daily discharges under 3,000 cfs were common during the dry season, now discharges of less than 4,500 cfs should be of unusual occurrence (Figure 3).

Savannah River at Augusta, Georgia (S-216)

Monthly mean discharges for 1952-1955 and yearly minimum daily discharges for 1939-1955 are presented respectively in Figures 2 and 3.

Prior to the construction of Clark Hill Reservoir the minimum instantaneous discharge of record was 648 cfs on September 24, 1939, and the minimum daily discharge of record was 1,040 cfs on October 2, 1927. The maximum daily discharge of record was 350,000 cfs on October 3, 1929, as compared with a maximum daily discharge of 22,400 cfs on April 15, 1955.

The area drained by the Savannah River at Augusta is 7,508 square miles.

Savannah River at Burton's Ferry Bridge (Millhaven)(S-129.25)

The minimum daily discharge of record was 2,120 cfs on September 9, 1951, compared with a minimum daily discharge of 4,770 cfs on December 29, 1954. The maximum discharge of record was 141,000 cfs on August 18, 1940, compared with a maximum daily discharge of 14,800 cfs on April 18, 1955.

The area drained by the Savannah River at Burton's Ferry Bridge is 8,650 square miles.

Savannah River near Clyo, Georgia (S-64.9)

A minimum daily discharge of 2,830 cfs was recorded on October 19 and 25 to 28, 1941, compared with a minimum daily discharge in 1954 of 5,310 cfs. A maximum discharge of 128,000 cfs was recorded on August 21 and 22, 1940, compared with a maximum daily discharge of 15,200 cfs on April 22 and 23,1955.

The Savannah River at the U. S. Geological Survey Gaging Station near Clyo drains an area of 9,850 square miles.

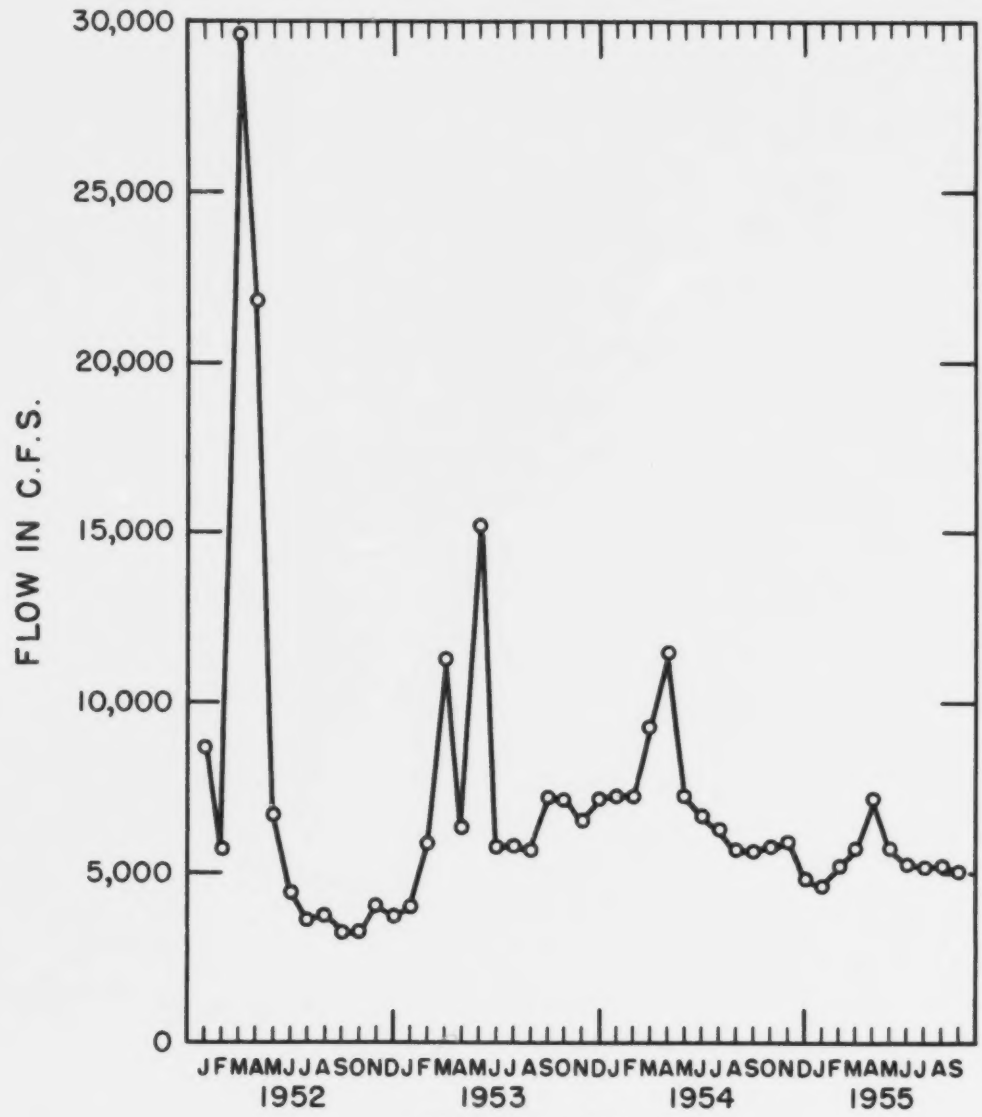
STREAM FLOWS AS RELATED TO WATER USES

Low stream flows occur concomitantly with warm dry weather and thus

intensify the effect of pollution on uses of the stream. By increasing the minimum expected flow in the Savannah River from about 2,000 cfs to at least 4,500 cfs, Clark Hill Reservoir has improved the ability of the river to dilute pollution and remain as an excellent source of water supply for the highest uses of water. Other benefits of increased flows during dry weather are reflected in increased navigation and recreation. Also, a more stable volume of water is available for use for domestic and industrial water supplies.

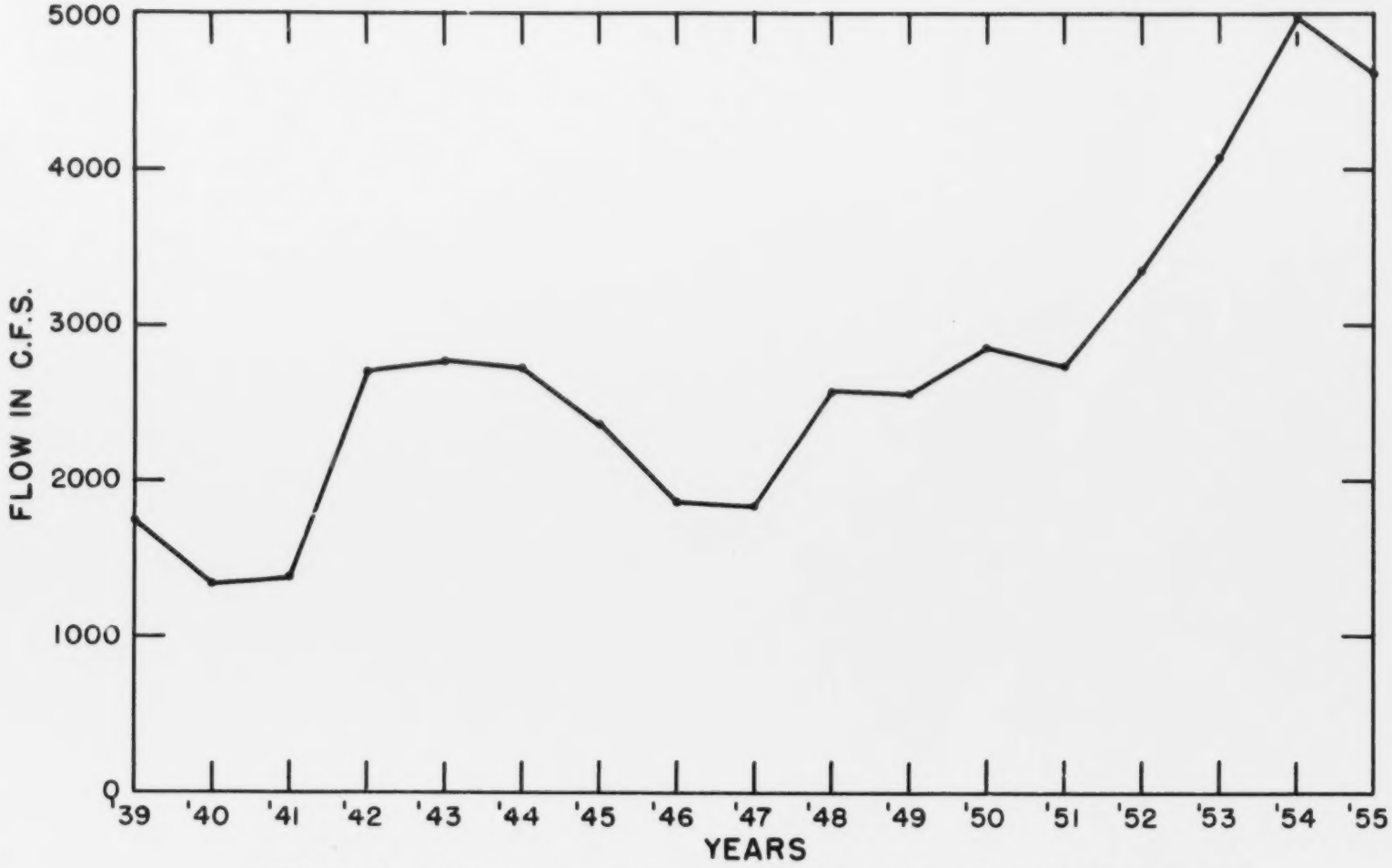
The principal pollution in the upper Savannah River is from Augusta, Georgia (S-216) which discharges about eighty-five per cent of its domestic sewage to the stream from Butler Creek at S-202.65. During the 1951-1952 studies sewage from Augusta flowed through a swamp area, before entering Butler Creek, and was oxidized to a considerable extent before being discharged to the Savannah River. Flows were increased by dredging operations in June and July of 1955, resulting in more rapid passage of sewage and an increased pollution load going into the river in 1955. The principal measurable effect of Augusta sewage is an increase in numbers of coliform bacteria 30 miles downstream, at the intake of the Atomic Energy Commission's Savannah River Plant. Fortunately the increased pollution is more than offset by increased dry weather flows, from 2,000 cfs, before Clark Hill Reservoir was put into operation, to at least 4,500 cfs with controlled flows. It is estimated that the additional 2,500 cfs is adequate dilution in the Augusta area for a population of about 250,000 people.

Downstream 120 miles from the Atomic Energy Commission's Savannah River Plant is the only user of the river as a source of water supply, namely the Cherokee Filtration Plant of the City of Savannah. The volume of water available for dilution and the time of flow from the Savannah River Plant to the Cherokee Filtration Plant make negligible the effect of organic pollution from this industrial operation.


30,000
25,000
20,000
15,000
10,000
5,000
0
FLOW IN C.F.S.
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1952
1953
1954
1955
MONTH AND YEAR

MONTHLY MEAN DISCHARGE AT AUGUSTA, GA.
FOR THE PERIOD, JAN. 1952 THRU SEPT. 1955
SAVANNAH RIVER STUDIES - 1955

FIGURE 2



YEARLY MINIMUM DAILY DISCHARGE AT AUGUSTA, GA.
SAVANNAH RIVER STUDIES - 1955

FIGURE 3

Preceding page blank

CHAPTER V

CHEMICAL, PHYSICAL, AND BACTERIOLOGICAL STUDIES

The routine physical and chemical examinations included those for temperature, turbidity, color, dissolved oxygen, hydrogen ion concentration (pH), chloride and methyl orange alkalinity. Some biochemical oxygen demand examinations were made at each sampling station.

Mineral analyses were not made during the 1955 studies. Such data that are used here were obtained from the U. S. Geological Survey.

Bacteriological work was limited to the determination of coliform bacteria, using both the MPN index and the membrane (Millipore) filter methods. For the MPN index three tubes of three dilutions were planted and incubated for 24 to 48 hours for the presumptive test. Samples showing gas formation were transplanted to brilliant green bile broth for confirmation. With the membrane filter method, enrichment and EHC Endo Media were used.

The analytical work was performed in accordance with Standard Methods for the Examination of Water and Sewage, Tenth Edition, 1955.[2/]

Special studies of the water quality of Clark Hill Reservoir are included here. Also, mention is made of water treatment plants in the Augusta area that keep routine data on water chemistry and bacteriology, even

---

2/ Prepared and published jointly by: American Public Health Association; American Water Works Association and Federation of Sewage and Industrial Wastes Associations.

though their data are not discussed in this report. During the 1955 studies, certain of their data were casually examined to determine the effect, if any, that closure of Clark Hill Reservoir might have had on water quality.

CHEMICAL AND PHYSICAL EXAMINATIONS

A summary of individual results of routine chemical and physical analyses of samples taken in the Savannah River from Woodlawn Landing (S-230.7) to the lower part of the estuarine portion (S-5) are presented in Appendix "A." The data are discussed in comparison with 1951-1952 data and some are presented graphically.

Temperature

There was very little temperature fluctuation at individual sampling stations in 1955.

The mean water temperatures in the upper Savannah River were as follows: Woodlawn Landing (S-230.7)-19.5°C; North Augusta Water Filtration Plant intake (S-218)-22°C; New Savannah Bluff Lock and Dam (S-203)-23°C; S-197, 23°C; S-172, 23.5°C and S-152, 24.5°C.

The low mean water temperature of 19.5°C at Woodlawn Landing (S-230.7) reflects the cold water releases from a 40 to 50 foot depth at Clark Hill Dam (S-238.1). During the period of studies such releases were warmed gradually by air temperatures as they passed downstream (i.e., 23°C at S-203, 22°C at S-218).

There were no appreciable differences in water temperatures during the 1955 studies compared with the same period during the 1951-1952 investigations.

Extensive water temperature data, relative to the Savannah River, including such from Clark Hill Reservoir, are on permanent file with the Savannah District Office of the Corps of Engineers, Savannah, Georgia.

Turbidity

The mean turbidities are shown in Figure 4. Turbidities increase as water moves down stream from Clark Hill Reservoir. The extremely high turbidities at S-14, S-11, and S-5 may have been caused, in part, by dredging operations that were being performed by the Corps of Engineers while the studies were in progress. (Figure 4)

During the 1951-1952 studies the minimum mean turbidity was 62 ppm and the maximum mean value was 115 ppm. Since the impoundment of waters behind Clark Hill Reservoir the minimum mean turbidity has been reduced to 7.1 ppm as determined by the 1955 studies.

From the standpoint of water use, the fact that the river above the estuarine portion is less turbid now is of much more significance than the increase in turbidity downstream.

Color

Mean values are presented for true color in Figure 5. From S-230.7 to S-172 the mean value was approximately 30 ppm. Color increased to 45.2 ppm at S-23 and rapidly decreased in estuarine water to a low of 13.6 ppm at S-5.

The decrease in color in estuarine water may be caused by adsorption of color by flocculation, as fresh and brackish water meet.

Mean color values during the 1955 studies were, in general, considerably lower than during the 1951-1952 studies (Figure 5). This may be a result of more stable discharge through controlled releases from Clark Hill Reservoir.

Swamp water contributes a considerable portion of the color increase in the lower river above estuarine water (Figure 5).

Alkalinity and Chlorides

Table 1 presents alkalinity and chloride data. Mean values show that there is but little variation in alkalinity and chlorides above tidal influence. Mean alkalinities range between 17 to 19 ppm and chlorides between 2 to 3 ppm. During the 1951-1952 studies mean alkalinities ranged between 15 to 17 ppm and chlorides between 3 to 4 ppm.

Hydrogen Ion Concentration (pH)

Hydrogen ion concentrations (pH) are shown in Figure 6. Just below Clark Hill Reservoir at S-230.7 the pH is lower than farther downstream. The amount of carbon dioxide, in releases from the reservoir, functions in depression of the pH at this station. The pH is elevated at S-218.5 as a result of the release of carbon dioxide in riffle areas between S-230.7 and this station. The pH fluctuations in the estuarine portion of the river result from industrial and domestic waste discharges and from the tidal influences of sea water.

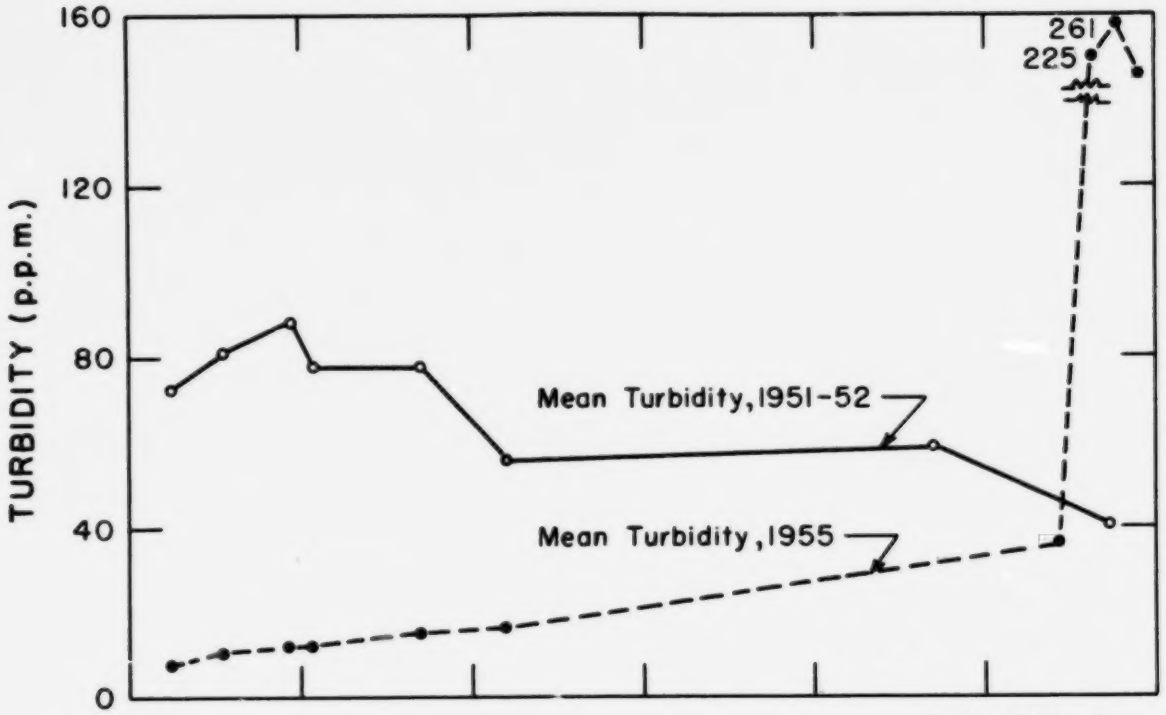
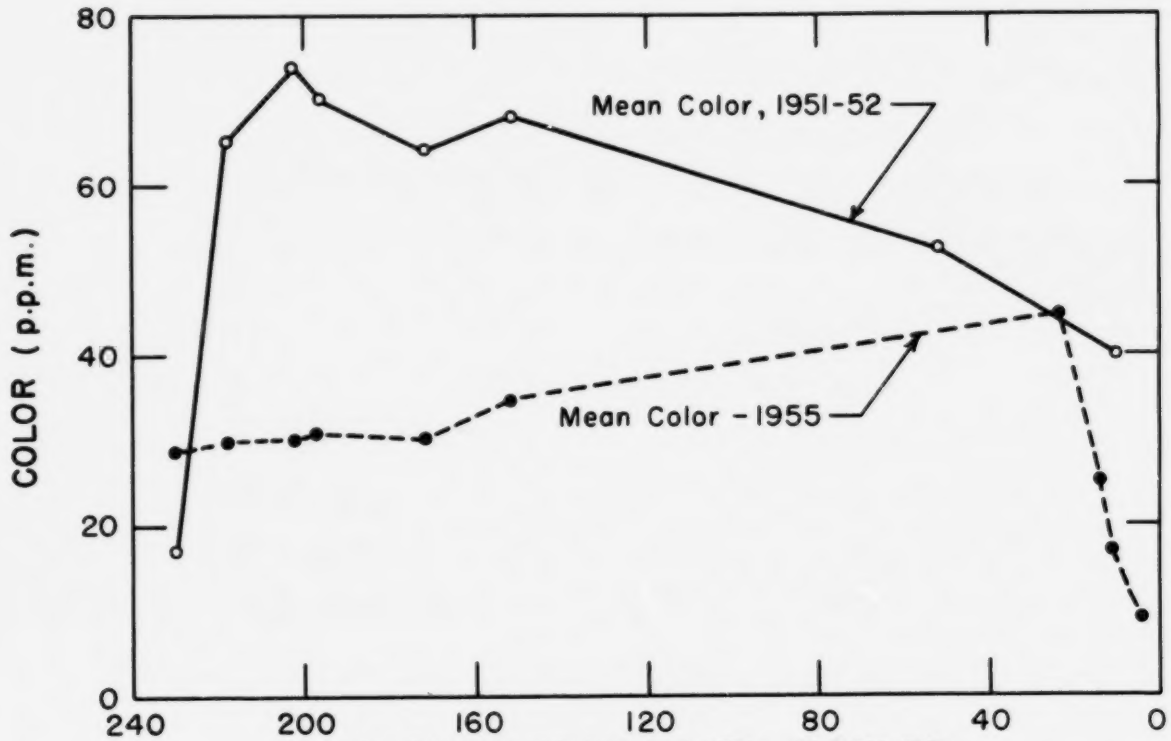


FIGURE 4



MEAN TURBIDITY AND COLOR VALUES
SAVANNAH RIVER STUDIES - 1955
COMPARISON OF 1951-52 DATA WITH 1955

FIGURE 5

TABLE 1

Mean Alkalinity and Chloride Values

Sampling Station	Alkalinity (M.O.) ppm	Chlorides ppm
S-230.7	17.8	2.9
S-218	17.5	2.1
S-203	18.8	2.3
S-197	18.6	2.1
S-172	18.4	2.2
S-152	18.3	2.2
S-28,Ab-2.5	20.7	3.0
S-23	21.6	5.2
S-14	42.6	1774.
S-11	56.5	3967.
S-5	78.6	9440.

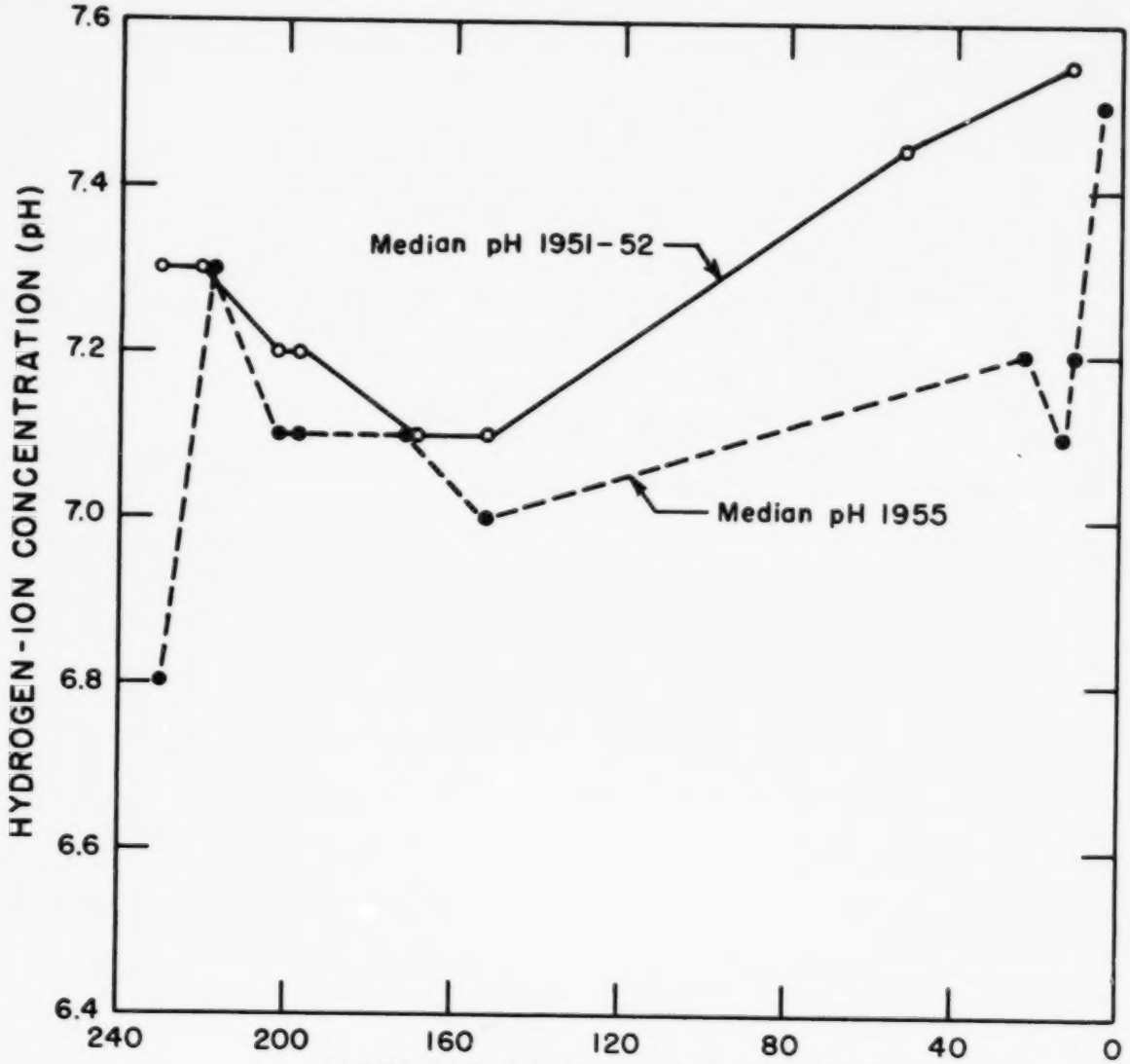
The variation of median pH values, between 1951-1952 and 1955 at individual stations, probably is a result of different seasons when samples were taken, and, in the upstream reach, also reflects the effect of reservoir water. During 1951-1952 the majority of pH analyses were made in the fall and winter as compared with summer analyses during the 1955 studies.

Dissolved Oxygen

Mean dissolved oxygen data are shown in Figure 7. They are plotted in terms of per cent of saturation to make them more comparable rather than as parts per million.

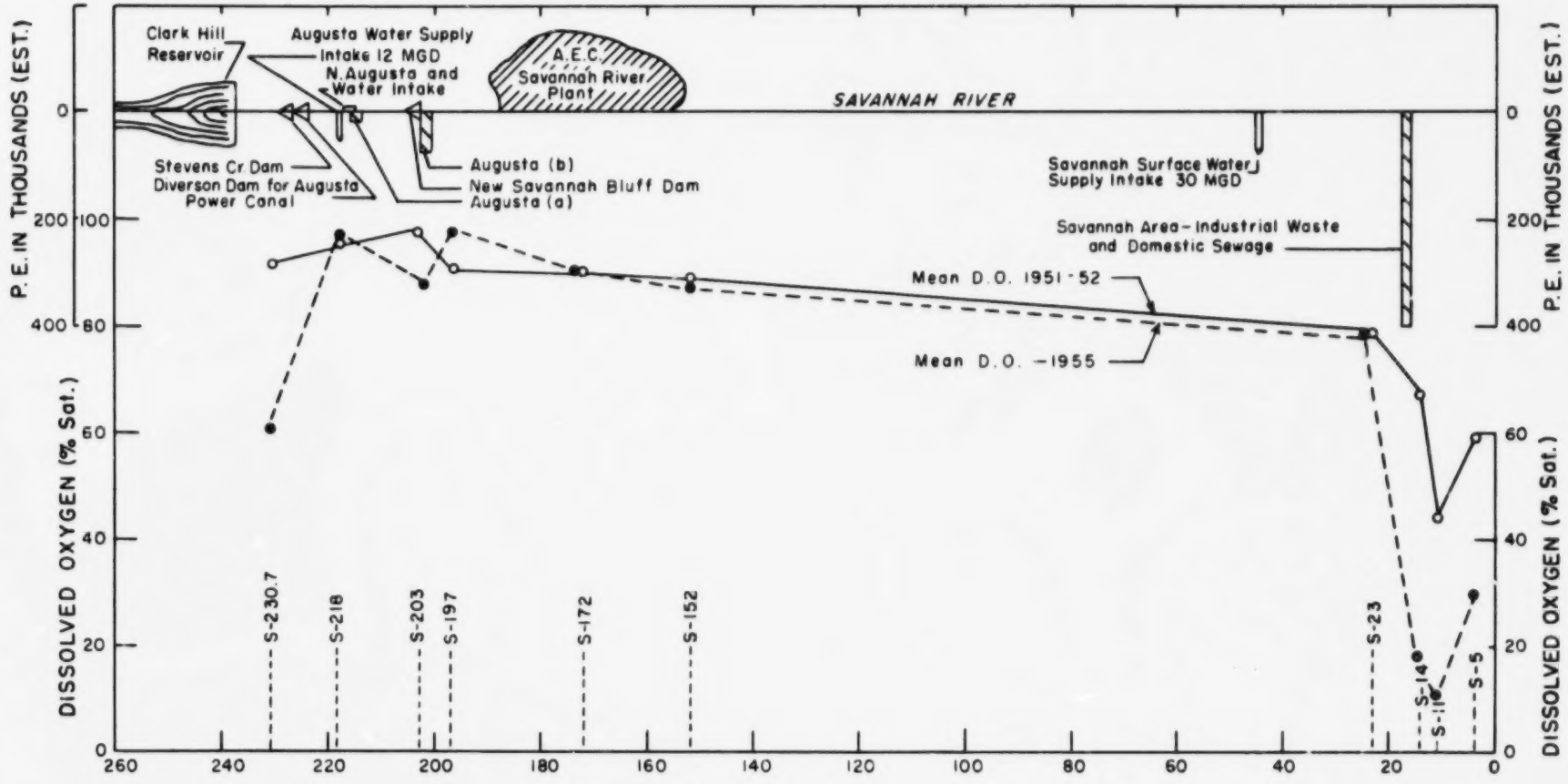
At S-230.7 dissolved oxygen was 61 per cent of saturation in 1955 compared with 95 per cent of saturation in 1951-1952. The lower figure in 1955 reflects the effect of Clark Hill Reservoir from which water, low in dissolved oxygen, is released from a fixed level of 40 to 50 feet below the surface. Water is aerated in riffle areas between S-230.7 and S-218.5, a mean value of 97 per cent of saturation occurring at the latter station as compared with a 96 per cent value in 1951-1952. Downstream to and including S-23 the per cent of saturation of dissolved oxygen remains high and compares favorably during both studies.

In estuarine water at S-14, S-11 and S-5 the mean per cent of saturation in 1955 was lower than in 1951-1952, but followed a similar pattern (Figure 7). The lower dissolved oxygen figures in 1955 may indicate that there has been an increase in industrial and/or municipal waste discharges in this reach of river.



MEDIAN pH VALUES
SAVANNAH RIVER STUDIES - 1955
COMPARISON: 1951-52 DATA WITH 1955

FIGURE 6



DISTANCE FROM MOUTH IN MILES

DISSOLVED OXYGEN

SAVANNAH RIVER STUDIES-1955

COMPARISON: 1951-52 DATA WITH 1955

FIGURE 7

Biochemical Oxygen Demand (B.O.D.)

In the upper Savannah River, from S-230.7 through S-152, B.O.D. values were less than 1 ppm (Figure 8). The highest value recorded was .75 ppm at Mile S-197, downstream from Butler Creek, S-202.65, which discharges about 75 per cent of Augusta sewage to the river.

The mean B.O.D. values of the 1955 studies, from S-230.7 to and including S-152, were slightly lower than those of the 1951-1952 studies (Figure 8). In the estuarine part of the river, S-14 to S-5, B.O.D. values were considerably higher than those of 1951-1952 (Figure 8). The higher B.O.D. values of 1955 can be accounted for by an increase in discharge of organic wastes in estuarine water.

Iron and Manganese

Iron and manganese determinations were made from samples taken at S-246.0 and S-239.1 in Clark Hill Reservoir, and at upper river stations S-230.7 to S-152.

Values for total and soluble iron for stations below Clark Hill Reservoir are presented in Figure 9. They indicate that total iron increases downstream while soluble iron remains consistent from S-202.9 to S-152.

In Clark Hill Reservoir both total and soluble iron increase with depth, being less in surface water than in deep water (Appendix "B"). In deep water (65 to 107 feet) soluble iron is equal to or greater than that measured at stations below the reservoir, while total iron is higher (Appendix "B").

Manganese values for stations below Clark Hill Reservoir vary from .05 ppm at S-230.7 to <.02 ppm at S-152. (Appendix "B").

In Clark Hill Reservoir manganese increases with depth, less than .004 ppm having been recorded from surface water to as much as 1.4 ppm at 77 feet (Appendix "B").

Extensive data relative to iron and manganese are in the permanent files of the Savannah District Office, Corps of Engineers, Savannah, Georgia.

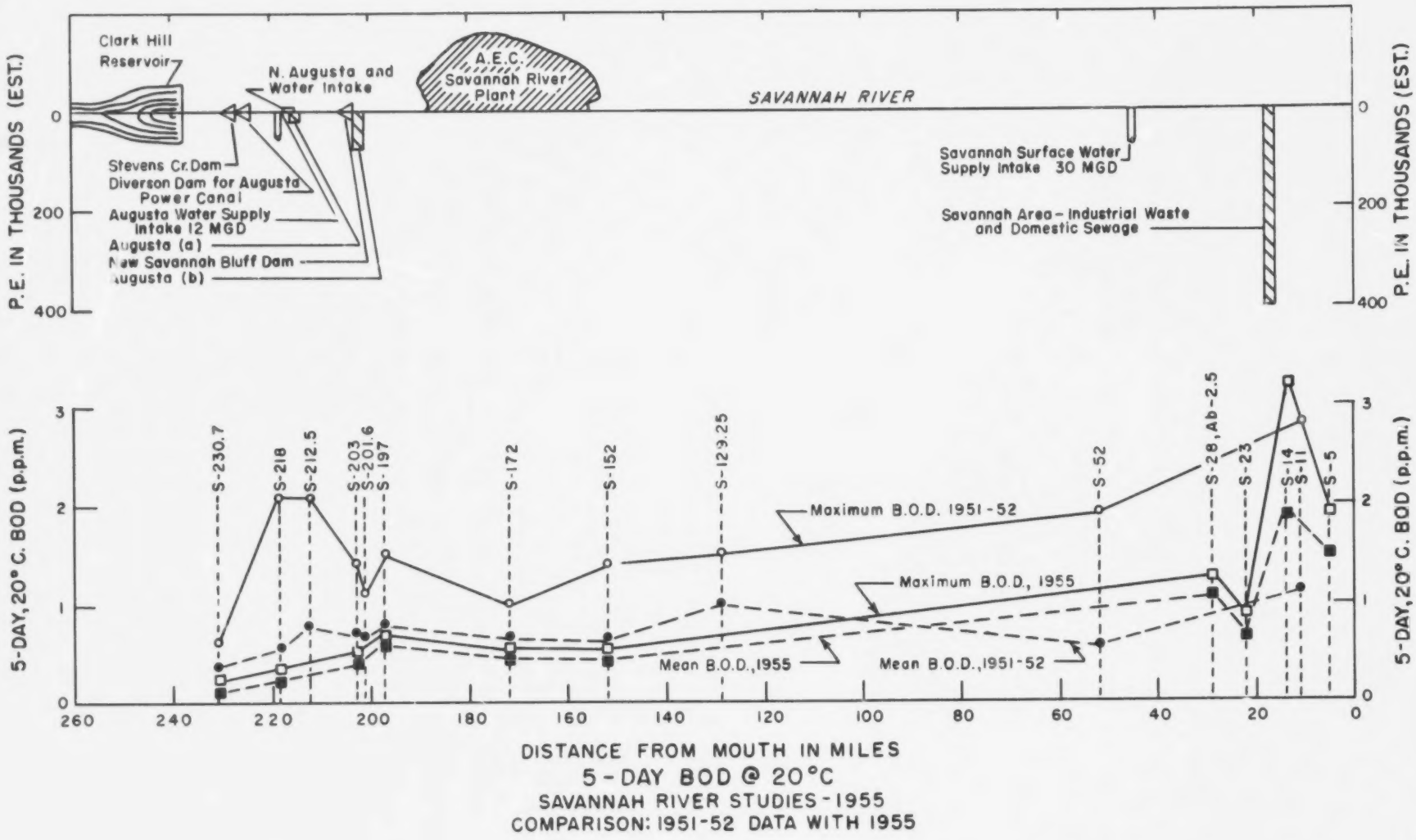
Mineral Analyses

No mineral analyses were made during the 1955 survey. Such data are presented for the Augusta area from those collected by the U. S. Geological Survey for the years 1951-1953. They indicate that somewhat similar mineral concentrations were found on the dates upon which the samples were collected (Appendix "B").

With river discharges controlled by Clark Hill Reservoir, fairly uniform mineral concentrations should continue to exist in the river at Augusta, Georgia (S-216.)

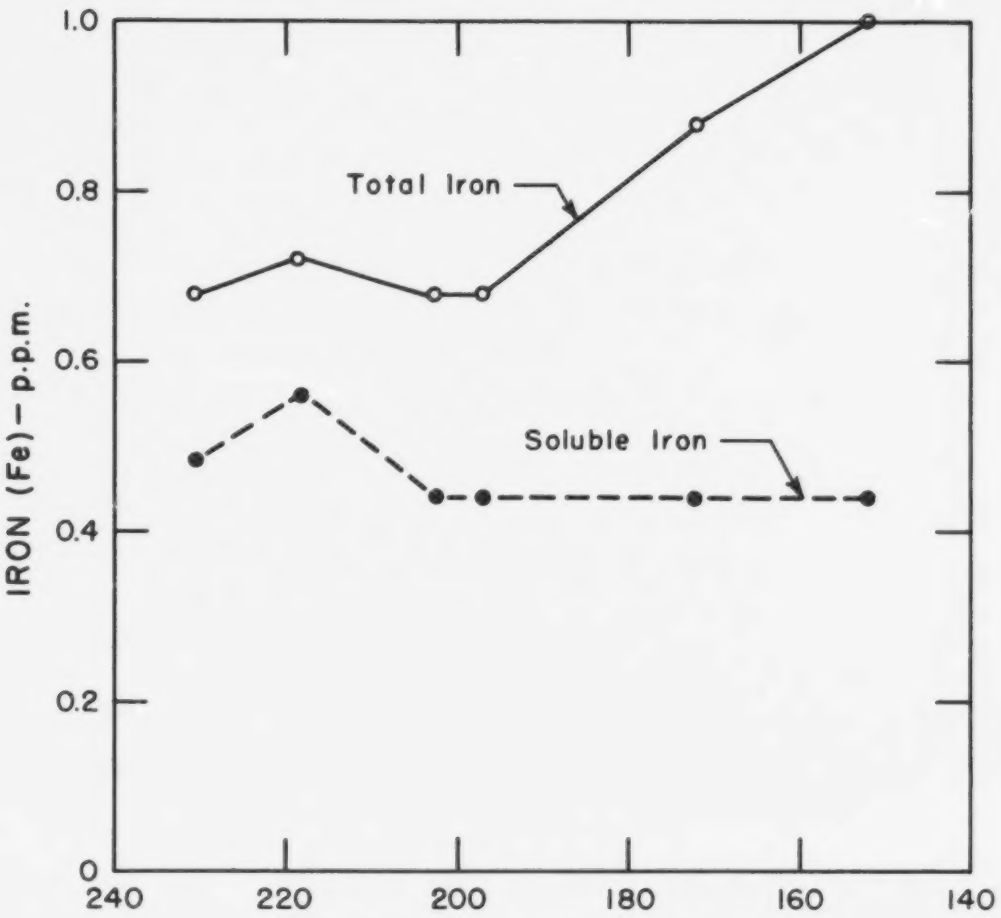
During the 1951-1952 studies, by the Public Health Service*/ it was found that relatively uniform mineral results were obtained when the river discharge at Augusta was below 10,000 cfs between October 31, 1951, and February 13, 1952. However, on March 13, 1952, when the mean daily discharge was 33,600 cfs, the total suspended solids and sulfate iron were increased 3.5 fold, while iron, dissolved solids, silica and fluorides were decreased about 3 fold.

*/ See Footnote 1, page 1



5 - DAY BOD @ 20°C
SAVANNAH RIVER STUDIES - 1955
COMPARISON: 1951-52 DATA WITH 1955

FIGURE 8



TOTAL AND SOLUBLE IRON CONTENT-JULY 7, 1955

SAVANNAH RIVER STUDIES – 1955

FIGURE 9

Suspended Load

Information relative to suspended load were not gathered in 1955. This discussion is based on data, for the years 1951-1954, that are on file in the Savannah District Office, Corps of Engineers, Savannah, Georgia. Sampling stations from which suspended load data were obtained are at the Clark Hill construction bridge, S-237.6, and at Clyo, S-64.9.

Since initiation of controlled discharge by Clark Hill Reservoir, December 20, 1951, the variations in suspended load concentrations have decreased considerably at the two sampling stations. Considerable decrease percentagewise in suspended load concentration has occurred at S-237.6; however, the load at Clyo (S-64.9), though consistently lower now than in 1952-1953, is only a small percentage decrease compared to that at S-237.6.

Before operation of Clark Hill Reservoir the suspended load varied considerably at both S-237.6 and S-64.9, and the load at S-237.6 was greater than that at Clyo about 50 per cent of the time and lower about 50 per cent. After reservoir operation began the suspended load has been consistently greater at Clyo.

BACTERIOLOGICAL EXAMINATIONS

Maximum, mean and minimum values obtained from bacteriological examinations of samples are shown in Figure 10. Data on individual water samples are presented in Appendix "A."

The highest MPN values recorded during the 1955 survey were found in the stretch of river from S-197 to S-172. Maximum values were 39,000 to

240,000 MPN per 100 ml. These high values can be attributed to Augusta sewage which discharges from Butler Creek at S-202.65 upstream from S-197.

The bacteriological results from the 1955 studies do not show any significant change when compared with those of the 1951-1952 studies.

SPECIAL DATA RELATING TO WATER QUALITY

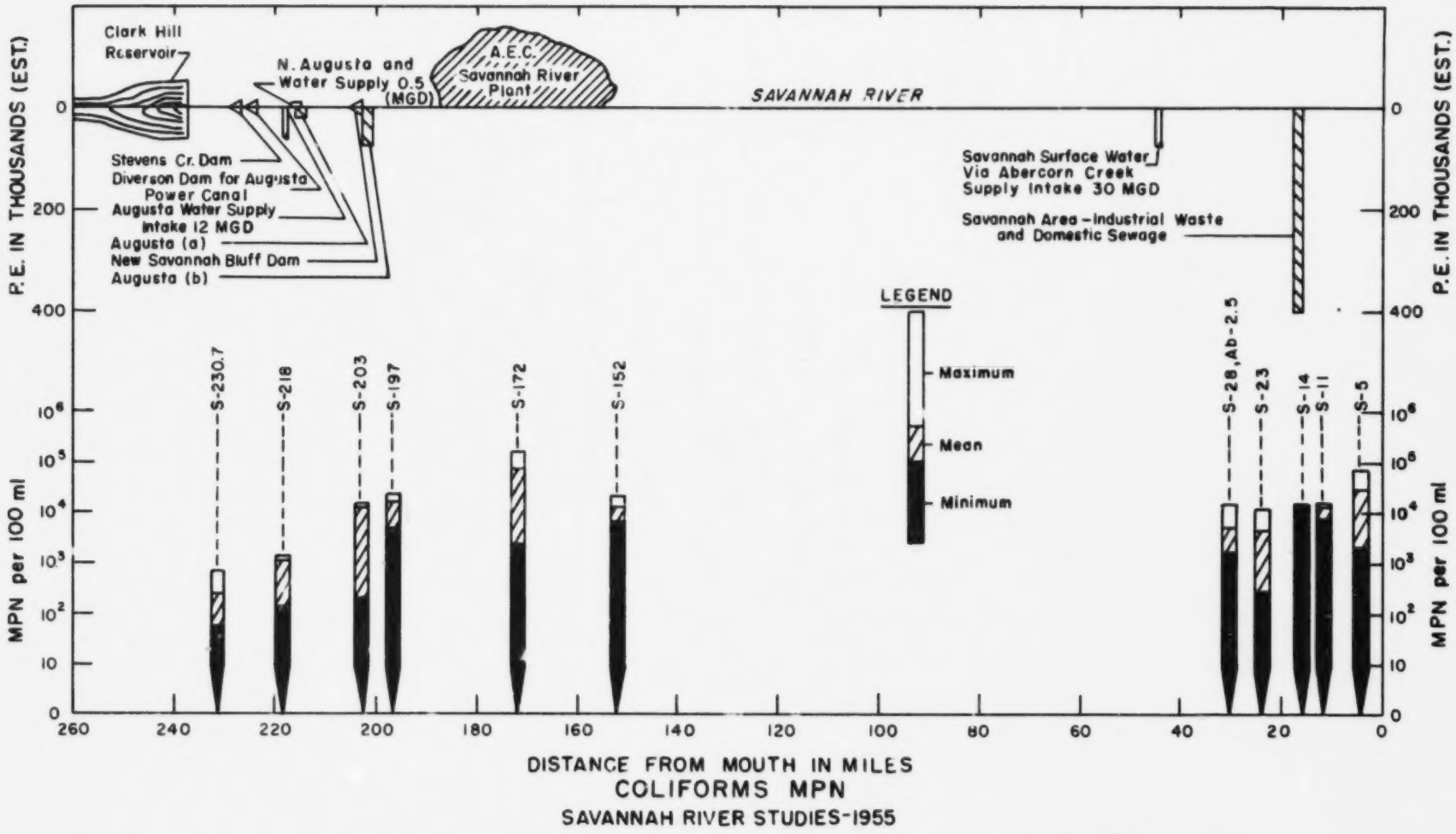
Clark Hill Reservoir Water Quality Studies

Certain data relating to the effects of Clark Hill Reservoir on downstream water quality have been discussed previously. Considered here are variations in chemical and physical analyses, relative to increases in depth in the reservoir. Determinations that were made include dissolved oxygen, temperature, pH, alkalinity, chlorides, color and turbidity (Appendix "C.")

Dissolved oxygen profiles at S-239.1, one mile above Clark Hill Dam, and at S-246 are shown in Figures 11 and 12. These figures show that dissolved oxygen is depleted in deep water as summer progresses. A similar condition is reported in the 1951-1952 studies.*/

With an increase in depth it was found that: pH values decreased from 7.6 at the surface to 6.9 at 70 feet; alkalinity increased from 16 ppm to 20 ppm; color and turbidity increased considerably from 7 ppm and 1 ppm, respectively, to 60 ppm and 25 ppm. Chloride values were variable and showed no particular trend with an increase in depth (Appendix "C.")

*/ See footnote 1, page 1.



COLIFORMS MPN

SAVANNAH RIVER STUDIES-1955

FIGURE 10

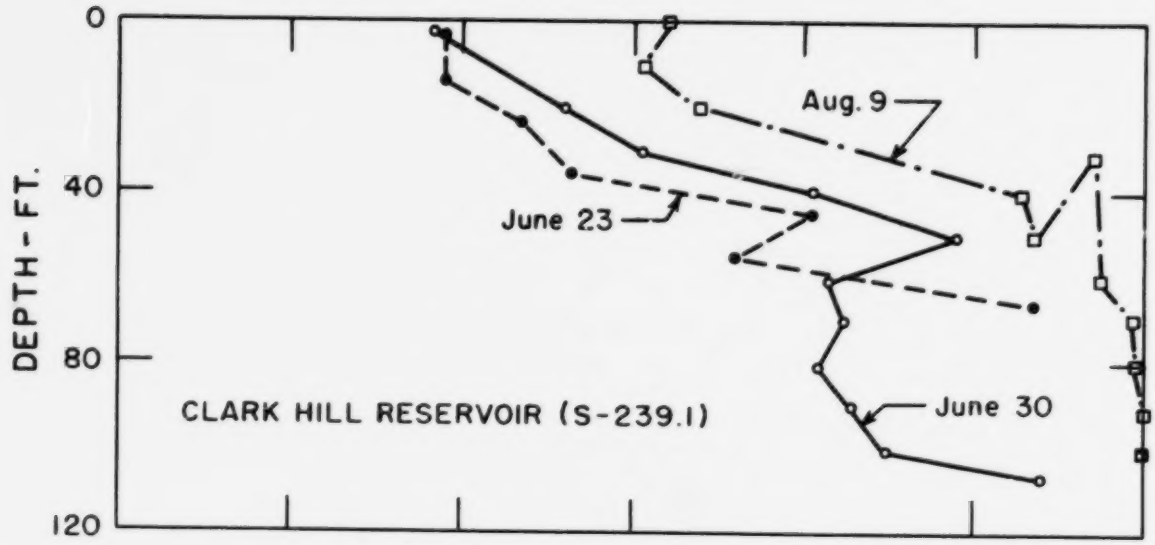
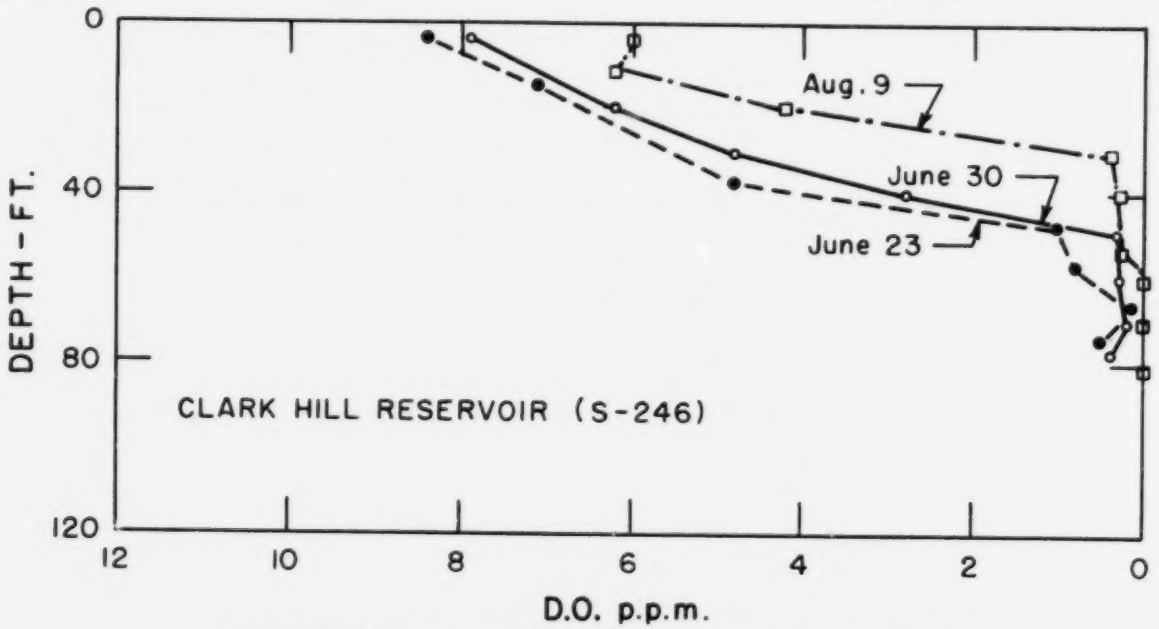


FIGURE 11



DISSOLVED OXYGEN - DEPTH RELATION
SAVANNAH RIVER STUDIES - 1955

FIGURE 12

Water Treatment Plant Water Quality Data

The existence of routine water quality data, that is collected by two water treatment plants in the Augusta area, is recorded here. Although such data were not pertinent to the preparation of this report, it was deemed advisable to use this document as a carrier of information relative to their existence, in event their use was desired in planning future surveys.

Augusta, Georgia, Water Filtration Plant

Data relative to turbidity, alkalinity, carbon dioxide, pH, and bacteriological plate counts on settled river water have been kept at this plant for a number of years. Such data, embracing the years 1945 through 1954, were made available for examination by the Public Health Service. Also, similar data on raw river water were made available. This plant has kept records relative to operations such as: hours of filter runs between back-washings, number of minutes filters washed, amount of wash water used, and amount of water used for coagulation.

North Augusta, South Carolina, Water Filtration Plant

Data relative to turbidity, carbon dioxide, alkalinity, pH, and bacteriological plate counts have been kept on raw river water from the beginning of plant operations in 1954.

CHAPTER VI

BIOLOGICAL STUDIES

A biological reconnaissance was made during July 16-21, 1955. In planning and carrying out such a survey it was deemed pertinent to obtain information, in a minimal time that could be used to: (1) index the biotic health of the river, (2) obtain plankton data that could be related to water treatment installations, and (3) assess recreational fishing and commercial fishing. Thus, biological data were gathered that could be related simply to floral and faunal lists of the earlier, comprehensive reports by the Academy of Natural Sciences of Philadelphia (1953)(1955)(1957) and by Gold, Scott, Hirsch, et al. (1954) of the Public Health Service.

Cognizance was taken of the fact that, since earlier surveys, changes in water quality and in physical characteristics of the river bed could have occurred as a result of stabilization of flows with the control of discharges by Clark Hill Dam and by changes in municipal and industrial pollution. Collections of macroscopic invertebrates were made with the aim of using them for general reference to assist in indexing possible significant changes in river environment as such might be correlated with degradation of water.

In planning the biological studies for 1955 it was agreed that allotting time to species identification would not be justified, and such effort would only provide subtile variations to the thoroughly documented lists of organisms in existing reports Anon (1953)(1955)(1957)*/ and Gold, Scott, Hirsch,

*/ Reports prepared by the Limnology Department of The Academy of Natural Sciences of Philadelphia.

et al. (1954). With these reports available to serve as comprehensive documents of Savannah River Biota, any extraordinary changes in aquatic life, related to changed river conditions, can be referenced and investigated, if in the future such is ever deemed desirable.

BIOLOGICAL COLLECTIONS RELATED TO BIOTIC HEALTH

Biological collections that were used to determine the biotic health of the river consisted largely of macroscopic invertebrates. These were taken at nine stations in reaches embodying miles: S-218.5, S-197, S-165.5, S-152, S-38 Ab 2.5, S-23, S-14, S-11, and S-5 (Figure 1). The latter three stations are in decided brackish water stretches. Thus, organisms occurring there cannot be compared, so far as their presence or absence is concerned, with those that form the biota of the upstream fresh water stations.

Collections were made at all stations by employing Petersen and Ekman dredges, hand nets, plankton nets and scrapers.

Representative associations of macro-invertebrates, comparable to those found during the 1951-1952 Public Health Service survey, were collected in 1955 (Table 2). Higher aquatic plants, algae, and various minnows were observed at all fresh water stations (S-218.5 through S-23). Fishermen were observed at each of these stations. No extraordinary unbalance of macro-invertebrate associations were found that could be attributed to an unbalanced environment, such as might result from severe municipal and/or industrial pollution at the fresh water stations.

The farthest upstream station that is below the greatest load of organic pollution is S-197, below the wastes from the City of Augusta area. The macro-invertebrates that were taken at this station did not reveal any associations that dominated, to the exclusion of unpolluted water associations. There was not any significant paucity of organisms at this station when compared with those found in other fresh water reaches. Organisms that have been associated with sludge deposits, resulting from organic pollution, that were found at this station were pulmonate snails and leeches and sparse mats of blue-green algae. However, these were also found at various other fresh water stations not associated with organic pollution. Sludge deposits that might have been associated with sanitary sewage at this station were absent.

As evidenced by presence of certain macro-invertebrates and absence of others, degradation of water and channel substrate was demonstrated in the brackish water reach from S-14 through S-11. Here extensive beds of sludge worms reflected the effect of settleable organic solids from sewage and industrial wastes that enter the river in the City of Savannah area. At the time collections were made at Stations S-14 and S-11, dredging operations were adding to the pollution load by stirring up and depositing silt and sand loads that were abnormal to this reach.

The dominant swimming macro-invertebrate at Stations S-14 and S-11 was the shrimp, Penaeus setiferus. This crustacean was twenty times more abundant on the South Carolina side than on the City of Savannah, Georgia, side of the river. Blue crabs, Callinectes sapidus, were collected swimming and in bank

Table 2. OCCURRENCE OF MACROSCOPIC INVERTEBRATES

General Categories	Stations								
	218.5	197	165.5	152	38 A62.5	23	14	11	5
Sponges (PORIFERA)					x	x			
Moss Animals (BRYOZOA)									x
Hydroids (COELENTERATES)								x	x
Flat Worms (PLATYHELMINTHES)	x								
Round Worms (NEMATHELMINTHES)		x					x		
Segmented Worms (ANNELIDA)									
Leeches (Hirudinea)	x	x	x						
Aquatic Worms (Oligochaeta)					x	x			
Sludge Worms (Oligochaeta)							x	x	
Marine (Polychaeta)									x
Arthropods (ARTHROPODA)									
Crustacea (Do)									
Sowbugs (Isopoda)						x	x		
Scuds (Amphipoda)					x	x		x	x
Crabs & Shrimp (Decapoda)					x	x	x	x	x
Barnacles (Cerripedia)							x	x	x
Insects (Insecta)									
Stoneflies (Plecoptera)	x			x	x				
Mayflies (Ephemeroptera)	x	x	x	x	x				
Dragon & Damselflies (Odonata)	x	x	x	x	x	x			
Bugs (Hemiptera)									
Water Striders (Gerridae)	x	x	x	x	x	x			
Back Swimmers (Notonectidae)		x	x	x	x				
Giant Water (Belostomatidae)		x		x		x			
Water Boatmen (Corixidae)	x	x	x	x	x				
Hellgramites (Megaloptera)	x					x			
Caddisflies (Trichoptera)	x	x	x	x	x	x			
Beetles (Coleoptera)									
Crawling Water (Haliplidae)	x								
Predaceous Diving (Dytiscidae)	x	x							
Whirligig (Gyrinidae)	x	x	x	x	x	x			
Scavenger (Hydrophilidae)	x	x	x						
Elmids (Elmidae)	x								
Flies (Diptera)									
Mosquitoes (Culicidae)								x	x
Midges (Tendipedidae)	x	x	x			x			
Biting Midges (Ceratopogonidae)			x	x					
Mollusks (MOLLUSCA)									
Gill Snails (Ctenobranchiata)	x		x		x	x		x	x
Lung Snails (Pulmonata)		x	x		x	x			x
Finger nail Clams (Sphaeriidae)	x	x			x				
Pearl Clams (Unionidae)	x	x	x	x		x			
Oysters (Osteridae)									x
TOTAL KINDS BY CLASS	18	16	14	11	15	15	5	7	10

holes at S-14 and S-11 only on the South Carolina side of the river. At S-5 these two crustaceans were taken in equal abundance in surface water from bank to bank across the channel. Fish were observed swimming in surface and cove waters at Station S-14 along the South Carolina shore and on both sides of the river at S-11 and S-5. Oysters, Crassostrea virginica, formed beds on the Georgia side of the stream at S-5. Two porpoises were seen in the channel at S-5. Oyster beds and porpoises were not observed at S-14 and S-11.

RELATIONSHIP OF PLANKTON TO WATER TREATMENT INSTALLATIONS

Operational records of water treatment installations, using the Savannah River as a raw water source, do not reveal data that can be used to demonstrate that plankton have interfered with treatment. With the decrease in turbidity (page 27) as a result of the impoundment of water behind Clark Hill Dam, it is conceivable that difficulties may possibly arise from plankton increases that can be correlated with increased filter backwashing frequency and with tastes and odors.

Plankton samples were taken at S-243 and S-239.1 at various depths in Clark Hill Reservoir; at S-222 on either side of the dam that diverts water from the Savannah River into the diversion canal from which the Augusta, Georgia, water treatment installation draws raw water, and at S-218.7 in the canal at the bar screens of this plant. Samples were also collected at S-218, the bar screen of the North Augusta, South Carolina, water treatment installation, and at S-38 Ab 2.5 at the bar screens of a pumping station of the Savannah, Georgia, water treatment installation. At the time plankton collections were made no visual blooms were apparent. No difficulties, attributable

to plankton, at water treatment installations were reported to persons who investigated this matter during the survey,

FISHING AND RECREATION

The 1954 Public Health Service Savannah River report, based on 1951-1952 investigations, stated that the value and importance of sport fishing on any large stream is difficult to assess. Further, it was stated that sport fishing on the river was apparently of negligible importance at the time of the studies. A prediction was made that, if the river became clearer with the operation of Clark Hill Dam and with population increase, sport fishing would increase.

Although records are not available to indicate number of fishermen present on the river during a specific time interval, some limited data on fishing pressure have been obtained. Fishing and recreation along the fresh water length of river appears to have increased from 1951-1952 to 1955 as based on general observations of personnel who were on both surveys. Counts of fishermen in 1955 indicated that the reach from Augusta Lock and Dam, S-222, to S-218 had the highest recreation fishing pressure for any reach of stream, based on counts of fishermen from a car reconnaissance. On July 30, 1955, forty-two fishermen were observed in this reach. Interviews indicated that fishing is now better with clearer water and more stable levels than had existed before controlled flows. Catfish and bream represented the majority of the fish caught. The next most frequented reach for recreational fishing was at the Savannah Bluff Lock and Dam at S-202.97 where thirty-one fishermen were observed on July 30, 1955. Fish that were reported as being caught over

a year were catfish, bream, carp, shad and striped bass.

Other recreational fishing areas of note, where either bank or boat fishing was observed, were:

1. Woodlawn Landing, South Carolina, S-230.7
2. Butler Creek, Georgia, S-202.65
3. Hancock Landing, Georgia, S-165.55
4. U. S. Highway Bridge No. 301, Georgia-South Carolina, S-129.25
5. Ebenezer Landing, Georgia, S-48.1
6. Lockners Landing, Georgia, S-46.33
7. Abercorn Creek, Georgia, S-38 Ab 2.5

During the period of the biological reconnaissance commercial fishing activity on the river appeared less than during the 1951-1952 survey. Only casual basket and trot line fishing were observed at Hancock Landing, Georgia, S-165.55, and trot line fishing at Abercorn Creek, Georgia, S-38 Ab 2.5. Fishermen from Springfield, Georgia, reported that commercial fishing continues to be established at Ebenezer Landing, Georgia, S-48.1, and at Lockners Landing, Georgia, S-46.33. Shad in season are taken at these stations and trot line fisheries exist for catfish. Relative to marine fisheries, fishermen reported that some 120 boats from Thunderbolt, Georgia, are engaged in commercial fishing for shrimp, flounder, and shellfish.

CHAPTER VII

BACKGROUND RADIOACTIVITY OF WATER, BIOTA, AND MUD

In this survey for radioactivity 43 water, 6 fish, 5 aquatic vegetation and 11 mud samples were collected and assayed at the Health Physics Building of du Pont, USAEC Savannah River Plant, Augusta, Georgia, for gross alpha and gross beta radioactivity. Radioactivity assays were made on the dissolved and suspended solids of water samples; on the flesh, bone, scales (if applicable), and stomach and intestine combined of the fish; on the aquatic vegetation (algae); and on the mud samples.

The gross alpha or beta radioactivity of these samples is made up of naturally occurring isotopes of the uranium and thorium series and naturally present beta emitters such as Potassium-40, possibly fallout or debris from nuclear weapons tests, and any radioisotopes produced locally which had not decayed prior to analysis of samples. Analyses were completed within seven days after sample collection.

RADIOACTIVITY OF WATER

Forty-three water samples from nine sampling stations were analyzed for the gross alpha and beta radioactivity associated with the suspended solids and the solids in solution.*/ Two water samples were not filtered and

*/ See Table 3.

were evaporated as rapidly as possible to obtain a total gross count of radioactivity to detect any short lived radioisotope. They showed no detectable short lived activity above the precision of the count.

The beta activity was appreciably higher than the alpha activity. Both were well below 100 micromicrocuries per liter (μμc/l.)*/ which is the maximum allowable concentration of undetermined mixtures of alpha or beta emitters which can be added to the radioactivity naturally present in water. The levels of activity were at the lower limits of detection of the methods used. The counting error at the 90% confidence level was used, and results were tabulated in μμc/l. plus or minus a precision of counting at the 90% confidence level.

The suspended solids alpha activity varied from zero to a maximum of 2.1 ± 1.7 μμc/l. of water. The soluble alpha activity of the sample containing the maximum suspended activity was 0.20 ± 1.8 μμc/l. Thus the total alpha activity of this sample was 2.3 ± 1.9 μμc/l. of water. This was the maximum total alpha activity of any sample. In the 1951-1952 survey the suspended solids alpha activity varied from zero to a maximum of 4.1 ± 1.7 μμc/l. of water. The soluble alpha activity of the sample containing the maximum suspended activity was 0.1 ± 1.1 μμc/l. Thus the total alpha activity of this sample was 4.2 ± 2.0 μμc/l. of water. The maximum alpha activity of any sample in 1951-1952 was 8.0 ± 2.1 μμc/l.

The beta activity was greater than the alpha activity. The maximum soluble beta activity was 60 ± 33.6 μμc/l. with an associated insoluble

*/ To convert micromicrocuries per liter (μμc/l.) to microcuries per milliliter (μc/ml.), multiply μμc/l. by 10^{-9}.

activity of 7.3 ± 32 µuc/l. for a gross total beta activity of 67.3 ± 33.6 µµc/l. This was the maximum gross total beta activity of any sample. In the 1951-1952 survey the maximum soluble beta activity was 23.1 ± 9.8 µµc/l. with an associated insoluble beta activity of only 0.2 ± 4.4 µµc/l. The maximum total beta activity found in any sample was 40.4 ± 15.6 µµc/l.

There is no apparent trend toward a higher level of activity downstream than upstream. The levels of sample activity were at the lower limits of detection by the methods used with the result that the associated statistical counting errors were large, and no increase in background radioactivity of the river water is indicated by these data. (Table 3).

RADIOACTIVITY OF BIOTA

Six fish were assayed, three separately, and three as a single composite sample. Radioactive assays were made on the flesh, bone, scales (if applicable), and stomach and intestine combined (viscera) of the fish. (Table 4).

The maximum alpha activity of fish flesh was 2.8 ± 0.61 µuc/gm of moist flesh weight while the maximum beta activity was 48 ± 7.3 µµc/gm of moist flesh. The maximum alpha activity of the fish flesh in 1951-1952 was 1.5 ± 0.9 µµc/gm of wet weight sample while the maximum beta activity was 11.6 ± 4.5 µµc/gm. The maximum alpha activity of ashed bone was less than the statistical counting error while the maximum beta activity was 146 ± 54 µµc/gm. In 1951-1952 both the maximum alpha and beta activity was less than the statistical error.

Table 3

Radioactivity of Savannah River Water Samples

River Mi.	Date Collected	Alpha Activity				Beta Activity			
		Suspended		Dissolved		Suspended		Dissolved	
		uuc/l	± uuc/l	uuc/l	± uuc/l	uuc/l	± uuc/l	uuc/l	± uuc/l
S-218.	7-25-55	0.22	0.54	-0.11	0.58	5.1	17	0.0	18
S-218.	7-27-55	0.0	0.60	0.36	0.77	13.7	17.6	17.2	19.2
S-218.	7-29-55			0.67	0.55*			20.2	15.2*
S-218.	8- 1-55	0.24	0.66	-0.4	0.43	-34.2	18	0.0	32
S-218.	8- 3-55	0.09	0.63	0.29	0.63	7.3	32	60.0	33.6
S-202.9	7-25-55	0.04	0.23	-1.0	0.34	-5.8	6	1.4	6.2
S-202.9	7-27-55	-0.35	0.31	-0.05	0.44	13.7	17.6	13.4	30
S-202.9	7-29-55			0.22	0.39*			15.3	16*
S-202.9	8- 1-55	1.0	0.86	0.95	0.60	-12.7	29.2	-14.4	15.0
S-202.9	8- 3-55	1.42	0.9	-0.20	0.63	-13.	29.2	11.6	30.4
S-202.4	7-25-55	1.25	1.05	0.2	0.37	11.1	9.6	18.8	9.0
S-202.4	7-27-55	-0.59	0.41	0.56	0.67	-44.	21.2	10.	32.
S-202.4	7-29-55			0.13	0.44*			8.8	15.*
S-202.4	8- 1-55	0.55	0.76	0.25	0.60	13.	31.6	13.2	29
S-202.4	8- 3-55	1.17	0.56	0.20	0.63	4.0	29.2	-20.	30.
S-172.	7-25-55	1.56	0.72	0.0	0.26	3.4	6.1	-5.1	6.8
S-172.	7-25-55	-0.35	0.38	0.12	0.50	0.0	18.	24.	17.4
S-172.	7-29-55	0.87	0.87	-0.45	0.56	-16.	19.2	-6.8	30.
S-172.	8- 1-55	0.27	0.59	-0.61	0.23	-8.	14.4	-3.4	9.6
S-172.	8- 3-55	1.27	1.06	0.68	0.68	1.5	32.	29.2	32.
S-164.	7-29-55	0.36	0.81	0.56	0.88	18.	18.	18.5	32.
S-164	8- 1-55	0.72	0.63	-0.19	0.18	-34.2	18.	-17.	32.
S-164	8- 3-55	0.36	0.81	-0.45	0.45	-32.	18.	-4.4	30

* Total (suspended and dissolved)

Table 3 (Continued)

Radioactivity of Savannah River Water Samples

River Mi.	Date Collected	Alpha Activity				Beta Activity			
		Suspended		Dissolved		Suspended		Dissolved	
		μμc/l	± μμc/l	μμc/l	± μμc/l	μμc/l	± μμc/l	μμc/l	± μμc/l
S-152.	7-25-55	1.26	0.54	0.07	0.22	6.8	7.0	20.	8.6
S-152.	7-27-55	1.53	0.95	0.53	0.76	-5.1	18.8	16.	32.
S-152.	7-29-55	0.72	0.87	0.11	0.43	-34.	19.2	-3.4	18.
S-152.	8- 1-55	0.24	0.56	0.13	0.30	10.5	19.2	0.68	14.8
S-152.	8- 3-55	0.61	0.72	-0.20	0.43	17.	17.6	-13.	29.
S-129.25	7-25-55	0.10	0.76	0.36	0.75	0.2	18.9	17.	18.
S-129.25	7-27-55			1.56	0.76*			18.	16.*
S-129.25	7-29-55			0.70	0.40*			6.7	7.4*
S-129.25	8- 1-55	0.76	0.76	0.6	0.79	-33.	18.	-1.5	32.
S-129.25	8- 3-55	0.47	0.72	0.20	0.63	11.7	33.6	2.7	29.6
S-38 Ab 2.5 (Abercorn Creek)	7-25-55	0.65	0.72	0.25	0.54	-24.	18.	24.	16.
"	7-27-55			0.39	0.34*			2.53	7.65*
"	7-29-55	0.54	0.54	1.55	0.79	3.1	18.	6.9	18.
"	8- 1-55	1.28	0.96	0.10	0.68	11.7	32.	18.	32.
"	8- 3-55	0.36	0.80	1.19	0.95	8.6	32.	-14.	32.
S-14.5	7-25-55	1.4	0.90	0.30	0.45	20.	18.	31.	18.
S-14.5	7-27-55	1.9	0.95	0.30	0.30	-20.4	18.	12.	32.
S-14.5	7-29-55			0.47	0.41*			30.	5.0*
S-14.5	8- 1-55	0.28	0.81	1.7	1.0	0.0	18.	-12.	32.
S-14.5	8- 3-55	2.1	1.7	0.20	1.8	-17.	29.	7.3	32.

* Total (suspended and dissolved)

Table 4

Radioactivity of Fresh Water Fish *

River Mi.	No./Sample		Date Collected	Flesh				Bone			
				Alpha uuc/gm	± Activity uuc/gm	Beta Activity uuc/gm	± uuc/gm	Alpha uuc/gm	± Activity uuc/gm	Beta Activity uuc/gm	± uuc/gm
S-165	Spotted Channel Cat. 78 gm	1	7-27-55	2.8	0.61	48.	7.3	-0.57	0.9	130	43
S-165	Spotted Channel Cat. 65 gm	1	8- 2-55	0.04	0.03	3.4	0.8	0.0	1.8	146	54
S-165	Blue Gill 16.8 gm	1	8- 3-55	0.02	0.03	-1.6	0.8	-4.0	4.3	0	156
S-210	Blue Gill	3	8- 3-55	0.04	0.04	2.2	2.8	-2.1	3.3	124	117

River Mi.	No./Sample		Date Collected	Viscera				Scales			
				Alpha uuc/gm	± Activity uuc/gm	Beta Activity uuc/gm	± uuc/gm	Alpha uuc/gm	± Activity uuc/gm	Beta Activity uuc/gm	± uuc/gm
S-165	Spotted Channel Cat. 78 gm	1	7-27-55	300.	29.	1267.	184.				
S-165	Spotted Channel Cat. 65 gm	1	8- 2-55	-1.5	3.5	43	109				
S-165	Blue Gill 16.8 gm	1	8- 3-55					4.5	2.3	-44	61
S-210	Blue Gill 11,16,& 22 gm	3	8- 3-55					-2.2	1.4	21	55

* Radioactivity of:
Flesh in uuc/gm of moist flesh ± uuc/gm
Bone in uuc/gm of ashed weight ± uuc/gm
Viscera in uuc/gm of ashed weight ± uuc/gm
Scales in uuc/gm of ashed weight ± uuc/gm

Sample No. 57 is a composite sample.

The channel catfish had appreciable beta activity that was detectable in the bone. One channel catfish had considerably more alpha and beta activity in its viscera than the other, as well as detectably higher activity in its flesh.

Five aquatic vegetation (algae) samples were assayed, and results of these analyses are presented in Table 5.

Table 5

RADIOACTIVITY OF FILAMENTOUS ALGAE

River Mile	Date Collected	Alpha Activity μμc/gm ± μμc/gm		Beta Activity μμc/gm ± μμc/gm	
S-218.7	7-16-55	0.92	0.5	-6.7	8.9
S-165.5	7-18-55	4.0	2.7	-3.9	5.8
S-152	7-18-55	0.63	0.21	2.3	3.4
S-38 Ab 2.5	7-19-55	3.3	1.3	12.	23.
S-5	7-20-55	0.54	0.1	1.6	13

The maximum alpha activity of algae was 4.0 ± 2.7 μμc/gm with the beta activity less than the statistical error of counting. In the 1951-1952 survey the maximum alpha activity was 3.4 ± 3.6 μμc/gm with the maximum beta activity 14.3 ± 5.6 μμc/gm. The apparent slight alpha activity increase may very well be due to traces of mud that was attached to the vegetation.

RADIOACTIVITY OF MUD

Eleven river bottom mud samples were assayed. The maximum alpha activity was 2.13 ± 0.43 μμc/gm while the maximum beta activity was 56.0 ± 5.0 μμc/gm. No direct comparison with the 1951-1952 survey can be made for mud samples.

Table 6

RADIOACTIVITY OF BOTTOM MUDS

River Mile	Date Collected	Alpha Activity μμc/gm ± uuc/gm		Beta Activity μμc/gm ± μμc/gm	
Abercorn Creek	7-22-55	0.83	0.34	38.4	3.5
S-202.9	7-29-55	0.96	0.34	13.	4.8
S-202.4	7-29-55	2.13	0.43	37.	5.0
S-172	7-29-55	0.68	0.32	12.	5.0
S-164	7-29-55	1.17	0.34	4.2	4.7
S-152	7-29-55	0.94	0.32	25.	5.1
S-129.2	8- 1-55	0.74	0.28	56.	5.0
S-38 Ab 2.5	8- 1-55	1.07	0.34	1.7	4.8
S-14.5	8- 1-55	1.97	0.48	15.4	4.6
S-11	7-22-55	1.28	0.33	37.6	3.5

CHAPTER VIII

BIBLIOGRAPHY

None of the various documents, containing information on Savannah River biota has yet to present a comprehensive bibliography of reports dealing with studies that have been conducted since 1950. Included in this chapter is a bibliography of reports that have been deposited with the Water Pollution Control unit of the Robert A. Taft Sanitary Engineering Center of the Public Health Service. The purpose of this bibliography is to present, in one document, information that can be readily noted by anyone who may contemplate further surveys of the Savannah River.

Writings that have so far emulated from Savannah River studies are categorized here as: (1) those dealing with diatometers, (2) those of a general survey nature, and (3) those dealing with the effects of temperature on algae and fish.

DIATOMETER REPORTS

1. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Oct. 1953-Dec. 1953, First Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 15 pp. March 1954.

2. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Jan. 1954-Mar. 1954, Second Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 11 pp. May 1954.

3. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Apr. 1954-June 1954, Third Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 11 pp. Sept. 1954.

4. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., July 1954-Sept. 1954, Fourth Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 11 pp. Oct. 1954.

5. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Oct. 1954-Dec. 1954, First Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 11 pp. Jan. 1955.

6. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Jan. 1955-Mar. 1955, Second Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 11 pp. Apr. 1955.

7. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., Apr. 1955-June 1955, Third Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 10 pp. July 1955.

8. Catherwood Diatometer Readings for the Savannah River Plant. E. I. du Pont de Nemours & Co., July-Sept. 1955, Fourth Progress Report. Acad. Nat. Sci. Phila., Dept. Limnology, 10 pp. Nov. 1955.

9. Catherwood Diatometer Readings for the Savannah River Plant. Oct.-Dec. 1955, First Progress Report, Third Year. Acad. Nat. Sci. Phila., Dept. Limnology, 10 pp. March 1956.

10. Catherwood Diatometer Readings for the Savannah River Plant. Jan.-Mar. 1956, Second Progress Report, Third Year. Acad. Nat. Sci. Phila., Dept. Limnology, 10 pp. May 1956.

GENERAL SURVEY REPORTS

1. Savannah River Biological Survey, South Carolina and Georgia, June 1951-May 1952. Final Report for E. I. du Pont de Nemours & Co., Acad. Nat. Sci. Phila., Dept. Limnology, 282 pp. Feb. 1953.

2. Interim Report on the Savannah River Studies, July 1951-July 1952. U. S. Department of Health, Education, and Welfare, Public Health Service, Bureau of State Services, Division of Sanitary Engineering Services, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 257 pp. Apr. 1954.

3. Savannah River Biological Survey, South Carolina and Georgia, Aug. 1954. Progress Report for E. I. du Pont de Nemours & Co. Acad. Nat. Sci. Phila., Dept. Limnology, 63 pp. May 1955.

4. Savannah River Biological Survey, South Carolina and Georgia, Aug.-Sept. 1955 and May 1956. Progress Report for E. I. du Pont de Nemours & Co. Acad. Nat. Sci. Phila., Dept. Limnology, 210 pp. March 1957.

REPORTS RELATING TO FISH AND ALGAE

1. Considerations on the Effects of High Temperatures on Algae and Fishes, A Literature Review. Prepared for The Savannah River Plant of E. I. du Pont de Nemours & Co. Acad. Nat. Sci. Phila., Dept. Limnology, 82 pp. May 1954.

2. The Effects of High Temperature on Catfish. Prepared for The Savannah River Plant of E. I. du Pont de Nemours & Co. Acad. Nat. Sci. Phila., Dept. Limnology, 17 pp. Aug. 1955.

3. A Study of the Movements of Channel Catfish, Ictalurus lacustris punctatus, in the Savannah River and Its Tributaries in the A. E. C. Savannah River Plant Area. Robert L. Humphries, University of Georgia, Ecology Studies, A. E. C. Savannah River Plant, 3 pp. (no date).

4. Temperature Tolerances of Algae and Fishes, A Literature Review. For E. I. du Pont de Nemours & Co. Acad. Nat. Sci. Phila., Dept. Limnology, 28 pp. 7 tables. (no date).

APPENDIX "A"

SUMMARY OF INDIVIDUAL RESULTS - SANITARY EXAMINATIONS

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Station	Date & Time 1955	Discharge at Augusta sec. ft.	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml
S-230.7	6/16 PM 4:08	5170	18	15	25	6.1	64	6.7	19	5.4	0		
	6/20 1:35 PM	5080	18	10	32	5.8	61	6.9	17	2.8	-	73	34
	6/21 2:30 PM	5360	20	8	23	6.2	68	6.8	17	2.0	-	-	-
	6/22 2:55 PM	5460	20	6	30	5.8	63	6.6	16	1.1	.26	-	-
	6/27 1:20 PM	5360	19	10	37	5.8	62	6.9	17	1.4	-	-	-
	6/28 1:30 PM	5360	20	9	32	5.7	62	6.8	18	1.2	-	930	38
	6/29 4:30 PM	5360	20	10	31	5.4	59	6.7	17	1.6	-	-	-
	7/1 1:00 PM	5080	20	7	28	5.1	55	6.7	19	7.2	.18	-	-
	7/5 1:00 PM	4980	20	8	24	6.2	68	6.8	18	1.7	-	210	48
	7/6 12:40 PM	5080	20	7	26	5.6	61	6.7	18	1.3	-	-	-
	7/7 1:10 PM	5080	20	8	28	5.0	55	7.0	20	6.4	-	-	-

Preceding page blank

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Station	Date & Time 1955	Discharge at Augusta sec. ft.	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml
S-218	6/16 4:30 PM	5170	21	10	25	9.3	103	7.4	19	.90	.26	-	-
	6/20 9:40 AM	5080	22	15	29	8.5	96	7.1	19	2.8	-	750	210
	6/21 12:25 PM	5360	22	10	23	8.2	93	7.0	17	2.3	-	-	-
	6/22 12:30 PM	5460	23	9	29	8.8	99	7.3	17	2.1	.14	-	-
	6/27 11:35 AM	5360	-	10	38	8.3	96	7.3	17	1.7	-	-	-
	6/28 11:45 AM	5360	22	8	31	8.8	100	7.3	17	2.0	-	230	190
	6/29 12:45 PM	5360	22	10	30	8.9	101	7.2	17	1.7	-	-	-
	7/1 11:50 AM	5080	22	8	32	7.9	90	7.2	18	3.5	.38	-	-
	7/5 10:15 AM	4980	22	15	30	8.1	92	7.2	18	3.6	-	2,400	110
	7/6 12:00 N	5080	22	7	28	8.9	101	7.3	17	1.7	-	-	-
	7/7 10:40 AM	5080	22	9	30	8.4	95	7.4	17	.8	-	-	-

Summary of Individual Results - Sanitary Examinations

Sampling Station	Date & Time 1955	Discharge at Augusta sec. ft.	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alka-linity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml
S-203	6/16 9:35 AM	5170	21	15	28	7.4	82	7.1	20	2.4	.57	-	-
	6/20 [illegible]:15 PM	5080	22	15	30	7.8	88	7.2	20	3.5	-	24,000	15,000
	6/21 11:05 AM	5360	22	10	24	7.9	89	7.2	19	2.1	-	-	-
	6/22 11:20 AM	5460	24	10	31	7.5	88	7.0	18	4.2	.51	-	-
	6/27 10:30 AM	5360	-	15	37	7.7	90	7.2	19	1.9	-	-	-
	6/28 10:50 AM	5360	24	10	29	7.5	88	7.1	18	1.6	-	24,000	6,600
	6/29 11:00 AM	5360	23	15	31	7.5	86	7.0	19	2.0	-	-	-
	7/1 10:45 AM	5080	22	10	32	7.5	85	7.0	19	2.0	.47	-	-
	7/5 12: N	4980	24	15	31	7.8	91	7.2	19	1.9	-	4,300	6,000
	7/6 10:10 AM	5080	24	7	28	7.8	91	7.1	18	1.8	-	-	-
	7/7 9:25 AM	5080	24	10	29	7.8	91	7.3	18	1.5	-	-	-

Sampling Station	Date & Time 1955	Discharge at Augusta sec. ft.	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform MPN/100 ml	Bacteria MF/100 ml
S-197	6/16 10:30 AM	5170	21	15	34	8.2	91	7.0	19	2.8	.70	-	-
	6/20 11:35 AM	5080	22	15	30	-	-	7.2	20	1.9	-	9,100	26,000
	6/21 9:55 AM	5360	22	15	33	8.7	98	7.0	18	1.7	-	-	-
	6/22 10:45 AM	5460	23	15	30	8.5	98	7.1	19	2.9	.80	-	-
	6/27 9:55 AM	5360	-	15	33	8.3	96	7.3	19	2.0	-	-	-
	6/28 10:15 AM	5360	24	10	30	8.4	98	7.1	17	1.8	-	24,000	55,000
	6/29 10:15 AM	5360	23	15	32	8.4	97	7.1	18	2.2	-	-	-
	7/1 10:17 AM	5080	22	9	31	8.6	97	7.1	19	2.0	.75	-	-
	7/5 11:30 AM	4980	24	15	31	8.5	100	7.2	19	1.8	-	39,000	9,900
	7/6 9:25 AM	5080	24	7	29	8.4	98	7.2	18	2.0	-	-	-
	7/7 9:25 AM	5080	24	10	29	8.1	95	7.3	19	1.9	-	-	-

SAVANNAH RIVER STUDIES - 1955 Summary of Individual Results - Sanitary Examinations

Sampling Station	Date & Time 1955	Discharge at Millhaven sec. ft.	Temp. °C	Turb ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml
S-172	6/16 11:40 AM	5400	22	15	33	8.1	92	7.0	19	2.4	.31	-	-
	6/20 10:30 AM	5680	22	15	26	7.9	90	7.1	20	2.1	-	43,000	20,000
	6/21 10:15 AM	5780	22	20	35	8.1	92	7.1	19	3.1	-	-	-
	6/22 10:10 AM	6060	23	20	34	8.1	93	7.1	18	2.5	.41	-	-
	6/27 10.30 AM	5590	24	15	33	7.8	91	7.2	19	1.8	-	-	-
	6/28 9:30 AM	5590	24	15	29	7.8	91	7.3	18	2.2	-	240,000	18,000
	6/29 9:25 AM	5590	24	15	30	7.9	93	7.1	17	2.0	-	-	-
	7/1 10:30 AM	5400	24	20	32	8.1	95	7.2	18	1.9	.55	-	-
	7/5 10:30 AM	5220	24	15	27	8.0	94	7.1	18	1.9	-	4,300	5,200
	7/6 10:15 AM	5500	24	10	24	7.8	92	7.1	18	2.5	-	-	-
	7/7 10:30 AM	5680	25	10	30	7.8	93	7.1	18	1.7	-	-	-

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Station	Date & Time 1955	Discharge at Millhaven sec. ft.	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chloride ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml
S-152	6/16 1:00 PM	5400	23	15	34	7.4	85	7.0	18	2.6	.37	-	-
	6/20 12:00 N	5680	23	20	37	7.2	83	7.0	19	2.1	-	7,500	7,100
	6/21 11:30 AM	5780	24	20	36	7.2	84	6.9	19	3.5	-	-	-
	6/22 11:15 AM	6060	24	20	40	7.4	87	6.9	17	2.0	.36	-	-
	6/27 11:30 AM	5590	24	15	33	7.7	90	7.2	19	1.9	-	-	-
	6/28 10:30 AM	5590	25	15	38	7.3	87	7.0	19	2.1	-	43,000	5,400
	6/29 10:30 AM	5590	25	15	35	7.4	88	7.0	18	2.5	-	-	-
	7/1 11:30 AM	5400	24	20	32	8.2	96	7.1	18	2.2	.61	-	-
	7/5 11:35 AM	5220	26	15	34	7.0	85	7.1	18	2.0	-	15,000	3,200
	7/6 11:15 AM	5500	26	15	34	7.1	86	7.0	18	1.8	-	-	-
	7/7 11:30 AM	5680	26	15	29	7.7	94	7.1	18	1.9	-	-	-

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Sta.	Date & Time 1955	Discharge at Clyo sec. ft.	Depth ft. from surface	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chlor. ppm	5-day 20°C BOD ppm	Coliform MPN/100 ml.	Bacteria MF/100 ml.	H	Tide L	
S-28, Ab-2.5	7/13 1:10 PM			27	60	130	4.3	53	6.6	19	2.5	1.3	11,000	20*	1438	845	near high
Abercorn Creek	7/14 10:25 AM			27	30	120	4.4	54	6.6	20	3.0	1.0			1547	949	near low
(Savannah W.P. Intake)	7/15 10:00 AM			28	35	120	4.2	53	6.7	21	3.4	1.1			409	1053	near low
	7/18 9:30 AM			31	30	33	6.6	88	7.2	21	4.0		2,400	240	737	1351	between mean and high
	7/19 9:05 AM			28	35	38	6.7	85	7.3	20	3.1				833	1444	near high
	7/20 9:20 AM			29	40	38	6.6	85	7.4	21	3.0				926	323	high
	7/21 7:10 AM			28	30	80	4.8	61	7.2	23	2.6				1014	411	mean

* - Inhibited by turbidity (probably)

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Sta.	Date & Time 1955	Discharge at Clyo sec. ft.	Depth ft. from surface	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	% Sat.	pH	Alkalinity ppm	Chlor. ppm	5-day 20°C BOD ppm	Coliform Bacteria MrN/100 ml	MF/100 ml	H	Tide L	
S-23	7/13 10:55 AM	6060	3	27	40	42	6.6	82	7.2	20	2.4	0.64	430	180	1438	845	between low & mean
			12	27	40	39	6.7	83	7.2	21	2.1	0.88					
	7/14 10:25 AM	6060	3	28	40	46	6.7	85	7.1	21	3.1	0.63			1547	949	near low
			18	28	50	46	6.7	85	7.2	21	2.0	0.35					
	7/15 9:30 AM	6060	3	28	40	60	6.4	81	7.2	21	3.7	0.45			409	1053	near low
			19	28	50	60	6.6	83	7.2	21	2.3	0.74					
	7/18 9:00 AM	6260	3	29	25	36	5.7	73	7.1	22	14.*		15,000	920	737	1351	between mean & high
			23	29	25	42	5.8	75	7.3	22	3						
	7/19 9:45 AM	5960	3	30	25	37	6.1	80	7.3	21	10				833	1444	near high
			17	30	30	39	6.2	81		21	2.8						
	7/20 10:30 AM	5760	3	29	30	42	5.3	68	7.3	23	10				926	323	near high
			18	30	30	44	5.4	71	7.3	23	3.2						
	7/21 8:50 AM	6160	3	29	40	50	6.0	77	7.5	23	12				1014	411	between mean & high
			15	29	40	50	6.1	78	7.4	23	2.4						

* Sampler probably not rinsed after sampling at S-14, at which Station the Chloride content of water is high.

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Sta.	Date & Time 1955	Discharge at Clyo sec. ft.	Depth ft. from surface	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chlor. ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml	Coliform Bacteria MF/100 ml	H	Tide L	
S-14	7/13 10:15 AM	6060	3	29	65	30	2.8	36	7.2	28	230	1.2	24,000	12,000	1438	845	between low & mean
			27	29	95	22	2.1	27	7.1	36	1,110	1.6					
	7/14 10:00 AM	6060	3	28	100	40	3.6	45	7.1	25	80	1.4			1547	949	low
			35	28	150	28	2.1	26	7.1	30	440	1.6					
	7/15 9:00 AM	6060	3	28	190	38	2.4	30	7.1	28	170	2.4			409	1053	between low & mean
			35	29	800	36	3.2	41	7.3	32	350	3.2					
	7/18 8:20 AM	6260	3	30	55	19	0.34	4.5	7.0	42	1,610		24,000	15,000	737	1351	near high
			43	30	100	15	0.72	9.4	7.2	64	5,800						
	7/19 9:00 AM	5960	3	30	80	22	0.40	5.2	6.9	43	1,310				833	1444	high
			37	30	65	18	0.50	6.5	7.2	56	3,790						
	7/20 9:50 AM	5760	3	30	85	19	0.07	.9	7.2	46	1,590				926	323	high
			41	30	140	18	0.29	3.8	7.3	68	5,280						
	7/21 7:50 AM	6160	3	30	230	24	0.03	.4	7.1	47	1,360				1014	411	mean
			41	30	1000	21	0	0	7.0	52	1,710						

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Sta.	Date & Time 1955	Discharge at Clyo sec. ft.	Depth ft. from surface	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chlor. ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml.	Coliform Bacteria MF/100 ml.	Tide H	Tide L	
S-11	7/13	6060	3	30	50	21	1.6	21	7.3	40	1,100	1.4	24,000	13,000	1438	845	near low
	9:55 AM		17	29	1300	22	1.4	18	7.2	44	1,390	1.8					
	7/14	6060	3	29	95	21	0.78	10	7.0	39	1,330	1.4			1547	949	low
	9:45 AM		25	28	700	17	0.53	6.7	7.2	52	3,480	1.5					
	7/15	6060	3	29	110	20	0.24	3.1	7.2	40	1,520	1.9			409	1053	between low and mean
	8:45 AM		35	29	190	23	0.54	6.9	7.2	43	2,090	1.3					
	7/18	6260	3	30			0.69	9.0					9,300	9,500	737	1351	high
	7:45 AM		45	30	95	14	1.6	21	7.4	76	8,350						
	7/19	5960	3	30	30	17	0.59	7.7	7.2	61	5,010				833	1444	high
	8:35 AM		33	30	60	14	1.2	15.7	7.4	72	7,150						
	7/20	5760	3	30	35	16	0.58	7.6	7.3	67	5,350				926	323	high
	9:30 AM		37	30	85	16	0.80	10.	7.4	79	7,870						
	7/21	6160	3	30	110	19	0.16	2.1	7.3	57	2,900				1014	411	mean
	7:20 AM		22	30	800	22	0.20	2.6	7.1	64	4,030						

SAVANNAH RIVER STUDIES - 1955

Summary of Individual Results - Sanitary Examinations

Sampling Sta.	Date & Time 1955	Discharge at Clyo sec. ft.	Depth ft. from surface	Temp. °C	Turb. ppm	Color ppm	Dis. Oxygen ppm	Dis. Oxygen % Sat.	pH	Alkalinity ppm	Chlor. ppm	5-day 20°C BOD ppm	Coliform Bacteria MPN/100 ml.	Coliform Bacteria MF/100 ml.	Tide H	Tide L	
S-5	7/13	6060	3	28	30	16	1.3	16	7.4	53	4,030	0.79	93,000	6,500	1438	845	near low
	9:25 AM		18	28	40	15	1.9	24	7.3	63	5,900	0.82					
	7/14	6060	3	29	40	15	0.87	11	7.2	55	4,660	0.85			1547	949	low
	9:30 AM		27	29	70	13	1.9	24	7.4	66	7,100	0.49					
	7/15	6060	3	30	60	11	1.1	14	7.4	61	5,790	0.98			409	1053	between M & L
	8:30 AM		33	29	550	12	3.0	38	7.6	83	10,200	1.1					
	7/18	6260	3	30	35	12	2.7	35	7.5	85	10,900		<3,600	1,400	737	1351	high
	7:00 AM		48	30	60	11	4.2	55	7.6	94	13,800						
	7/19	5960	3	30	30	13	2.5	33	7.5	84	10,500				833	1444	high
	8:10 AM		41	30	120	11	4.2	55	7.7	101	15,000						
	7/20	5760	3	30	40	14	2.2	29	7.5	87	11,300				926	323	high
	9:00 AM		32	30	120	14	3.6	47	7.6	97	14,000						
	7/21	6160	3	30	45	16	1.3	17	7.5	80	8,390				1014	411	mean
	6:50 AM		45	30	800	17	2.0	26	7.5	92	10,600						

APPENDIX "B"

SUMMARY OF IRON AND MANGANESE RESULTS,

and

U. S. GEOLOGICAL SURVEY MINERAL ANALYSES

Iron and Manganese Results
from Savannah River Studies, S-230.7 through S-152
(Results in ppm)

Sampling Station	Date 1955	Discharge cfs	Iron		Manganese, Soluble
			Soluble	Total	
		At Augusta			
S-230.7	7/7	5080	0.48	0.68	.05
S-218	"	5080	0.56	0.72	.02
S-202.9	"	5080	0.44	0.68	.03
S-197	"	5080	0.44	0.68	.03
		At Millhaven			
S-172	"	5680	0.44	0.88	.03
S-152	"	5680	0.44	1.0	<.02

Iron and Manganese Results
from Clark Hill Reservoir
(Results in ppm)

Sampling Station	Date 1955	Depth	Iron		Manganese, Soluble
			Soluble	Total	
S-246	6/23	3	0.08	0.14	<.004
(6.9 miles	"	47	0.64	0.88	0.54
above	"	74	0.56	2.2	0.76
Clark Hill Dam)	6/24	3	0.18	0.34	<.02
	"	40	0.60	0.76	<.07
	"	80	1.12	2.9	0.76
	6/30	3	0.08	0.14	<.02
	"	50	0.54	0.84	0.58
	"	77	0.56	1.1	1.4
S-239.1	6/23	3	0.06	0.10	<.004
(One mile	"	45	0.38	0.60	<.004
above	"	65	1.5	3.9	1.2
Clark Hill Dam)	6/24	3	0.10	0.16	<.02
	"	58	0.52	0.64	<.02
	"	105	1.3	1.5	0.38
	6/30	3	0.06	0.10	<.02
	"	60	0.46	0.52	<.02
	"	107	1.5	1.8	.64

Mineral Analyses of Savannah River Water
at Augusta, Georgia, S-216 (Data of U. S. Geological Survey)
(Results in ppm)

	Nov. 6, 1951	June 3, 1952	Oct. 20, 1952	Nov. 10, 1953
Mean Daily Discharge (cfs)	4,980	4,540	3,260	6,530
Temp. ^{o}F	58	71	69	60
Silica (SiO_2) ppm	14	11	11	12
Iron (Fe)	.05	.09	.02	.08
Calcium (Ca)	3.4	3.9	3.6	3.7
Magnesium (Mg)	1.3	1.5	1.4	1.2
Sodium (Na)	5.5	6.0	5.8	5.3
Potassium (K)				
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	22	26	25	23
Sulfate (SO_4)	2.4	3.1	2.8	2.1
Chloride (Cl)	3.0	2.4	2.4	2.5
Fluoride (F)	.2	.1	0	.1
Nitrate (NO_3)	.7	1.0	.8	1.1
Dissolved solids	42	42.	40.	41.
Total Hardness (as $CaCO_3$)	14	16	15	14
Color	15	12	12	16
pH	6.4	7.3	6.5	6.3
Specific conductance (micoomhos at 25°C)	51.3	53.9	77.9	88.1

APPENDIX "C"

CLARK HILL RESERVOIR

SUMMARY OF INDIVIDUAL RESULTS OF WATER QUALITY

Summary of Individual Results of Water Quality
(Results in ppm)

Station	Date 1955	Depth Feet	Temp.	D.O.	pH	Alk.	Cl.	Color	Turb.
S-246	6/23	3	28	8.4	7.4	15	1.6	13	3
		17	25	7.3	7.0	16	1.4	13	5
		37	24	4.8	6.8	16	1.1	36	10
		47	22	1.0	6.9	19	1.1	46	20
		58	20	0.78	6.8	21	1.8	37	15
		67	19	0.16	6.6	21	1.7	38	15
		74	18	0.51	7.1	21	2.2	43	70
	6/24	3	27	8.4					6
		20	25	7.1					5
		30	24	6.6					5
		40	23	3.7					15
		50	21	1.4					20
		60	20	1.2					20
		70	19	1.3					15
		80	18	1.0					85
	6/30	3	28	7.9	7.6	16	2.0	8	2
		20	26	6.2	7.2	15	2.2	14	5
		30	24	4.8	6.9	15	2.4	21	10
		40	24	2.8	7.1	17	2.1	27	15
		50	22	0.3	7.0	19	2.3	24	15
		60	20	0.3	6.8	23	1.7	27	20
		70	22	0.2	6.9	20	2.0	21	15
		77	18	0.4	7.0	22	1.9	38	20
	8/8	3	32	6.7					
		10	31	6.5					
		20	30	5.7					
		30	28	0.9					
		40	26	0.6					
		50	25	0.2					
		60	24	0					
		70	22	0					
	8/9	3	30.5	6.0					
		10	30.5	6.2					
		20	30	4.2					
		30	27	0.4					
		40	26	0.3					
		50	24	0.3					
		60	24	0					
		70	22	0					
		80	19	0					

Summary of Individual Results of Water Quality
(Results in ppm)
(Continued)

Station	Date 1955	Depth Feet	Temp.	D.O.	pH	Alk.	Cl.	Color	Turb.
S-246 (cont.)	8/11	5	29	5.8					
		15	29	5.1					
		25	28	2.7					
		35	26	0.2					
		45	26	0.6					
		55	24	0.2					
		65	22	0					
		75	21	0					
Modoc Mile ?	8/8	3	32	6.1					
		12	31	7.2					
		22	29	4.8					
	8/9	3	30	5.6					
		12	30	4.6					
		22	29	3.3					
	8/11	3	30	5.1					
		10	29	4.7					
		20	29	4.9					
		30	28	0.2					
S-239.1	6/23	3	28	8.2	7.6	16	2.5	11	2
		15	25	8.2	7.5	16	2.0	11	1
		25	25	7.3	7.4	16	1.2	12	2
		35	24	6.7	7.4	16	1.8	16	4
		45	22	3.9	6.9	17	2.0	34	10
		55	20	4.8	6.9	18	1.3	32	15
		65	16	1.3	7.1	20	1.7	85	10
	6/24	3	28	8.2					2
		18	27	8.2					2
		28	26	7.4					4
		38	24	5.6					5
		48	23	3.5					10
		58	23	4.6					10
		68	22	3.8					15
		78	22	4.5					9
		88	17	4.6					20
		98	16	4.8					20
		105	16	2.3					25
	6/30	3	26	8.3	7.5	15	2.0	7	1
		20	25	6.8	7.1	17	1.8	8	2
		30	25	5.9	7.0	14	1.8	9	3
		40	23	3.9	6.9	16	1.6	16	6
		50	22	2.2	6.8	16	1.8	19	9

Summary of Individual Results of Water Quality
(Results in ppm)
(Continued)

Station	Date 1955	Depth Feet	Temp.	D.O.	pH	Alk.	Cl.	Color	Turb.
S-239.1 (Cont.)	6/30 (Cont.)	60	20	3.7	6.9	18	1.8	33	9
		70	19	3.5	6.8	18	2.0	36	10
		80	19	3.8	6.7	16	2.1	35	15
		90	16	3.4	6.8	19	2.0	41	15
		100	20	3.2	6.9	16	2.2	34	15
		107	16	1.2	6.8	17	2.3	60	25
	8/8	3	31	7.4					
		15	30	6.9					
		25	28	1.9					
		35	26	0.5					
		45	22	1.4					
		55	22	0.8					
		65	22	0.6					
		75	15	0.4					
		85	15	0.3					
		95	14	0.3					
		105	13	0.3					
		115	12	0.5					
	8/9	0		5.6					
		10	30	5.9					
		20	29	5.2					
		30	27.5	0.6					
		40	25	1.4					
		50	24	1.3					
		60	23	0.5					
		70	20.5	0.2					
		80	20	0.1					
		90	19	0					
		100	16	0					
	8/11	5	30	4.0					
		15	29	3.9					
		25	29	4.0					
		35	28	3.7					
		45	26	0.4					
		55	24	0.5					
		65	24	0.2					
		75	22	0					
		85	19	0					
		95	18	0					
		105	17	1.4					

APPENDIX "D"

MONTHLY MEAN DISCHARGE DATA

from

U. S. GEOLOGICAL SURVEY

Monthly Mean Discharge Data in cfs

(From U. S. Geological Survey)

(Jan. 1952 - Sept. 1955)

Month	Augusta, Georgia (S-216)	Burton's Ferry Bridge (Millhaven, Georgia) (S-129.25)	Clyo, Georgia (S-64.9)
1/52	8,650	9,920	11,590
2/52	5,840	7,320	8,910
3/52	29,090	28,710	27,930
4/52	21,810	26,620	31,150
5/52	6,780	8,170	10,040
6/52	4,340	4,710	5,680
7/52	3,630	4,180	4,640
8/52	3,890	4,630	5,020
9/52	3,330	4,090	4,500
10/52	3,380	4,070	4,780
11/52	4,020	4,810	5,330
12/52	3,750	4,680	5,260
1/53	4,080	5,650	6,550
2/53	5,890	7,140	8,320
3/53	11,390	13,350	16,130
4/53	6,460	8,970	11,540
5/53	15,150	16,640	18,160
6/53	5,780	6,880	7,510
7/53	5,750	6,570	6,700
8/53	5,700	6,310	6,560
9/53	7,230	8,060	8,200
10/53	7,170	7,910	9,260
11/53	6,500	7,320	7,900
12/53	7,120	8,410	9,840

Monthly Mean Discharge Data in cfs

(From U. S. Geological Survey)

(Jan. 1952 - Sept. 1955)
(Continued)

Month	Augusta, Georgia (S-216)	Burton's Ferry Bridge (Millhaven, Georgia) (S-129.25)	Clyo, Georgia (S-64.9)
1/54	7,250	8,610	9,810
2/54	7,270	8,010	8,480
3/54	9,420	9,430	10,880
4/54	11,460	12,660	14,120
5/54	7,310	7,790	8,950
6/54	6,580	6,590	7,090
7/54	6,230	6,420	6,650
8/54	5,680	5,840	5,960
9/54	5,580	5,740	5,890
10/54	5,790	5,880	5,920
11/54	5,850	6,200	6,470
12/54	4,930	5,520	6,080
1/55	4,600	5,590	6,350
2/55	5,280	6,260	7,320
3/55	5,770	6,400	7,050
4/55	7,120	8,100	9,760
5/55	5,810	6,330	7,210
6/55	5,230	5,650	6,310
7/55	5,210	5,600	6,230
8/55	5,230	5,630	6,250
9/55	5,000	5,250	6,570

APPENDIX "E"

DESCRIPTION OF THE PROCEDURES USED FOR ASSAYING THE RADIOACTIVITY IN FRESH WATER, BIOTA, AND MUD

APPENDIX "F"

DESCRIPTION OF THE PROCEDURES USED FOR ASSAYING THE RADIOACTIVITY IN FRESH WATER, BIOTA, AND MUD

RADIOACTIVITY OF WATER

The procedure used for assaying the radioactivity in fresh water was as follows:

(1) Suspended Solids

Weigh a membrane filter in an aluminum dish. Filter 250 or 500 ml. of the well mixed water sample through the membrane filter. Save the filtrate for part 2. Replace the filter in the aluminum dish and allow the membrane filter plus the suspended solids to dry for one hour in an oven at 110°C with a glass ring on the periphery of the filter to hold the filter flat, cool, reweigh and count for alpha and beta activity.

(2) Dissolved Solids

Process the filtrate from (1) by beaker evaporation on a hot plate maintaining the temperature so that the water is just boiling and evaporate to near dryness. The beakers are then washed down with 2 N nitric acid and a rubber policeman twice and evaporated down to pipetting volume (approximately 1 to 2 ml.) and pipetted to a flamed preweighed stainless steel counting dish each time. Evaporation to dryness on the stainless steel planchet was accomplished by use of a heat lamp above and

below the planchet. When completely dry, flame (hold planchet in bunsen burner flame for a few seconds), cool, reweigh, and count for alpha and beta activity. A few very clear samples were not filtered and were evaporated directly.

(3) Special

Two 100 ml. samples without filtering were evaporated as rapidly as possible and counted the same day for gross alpha and beta activity.

RADIOACTIVITY OF BIOLOGICAL SAMPLES

The procedure used for assaying the radioactivity was as follows:

All biological and aquatic vegetation were dry ashed. Appropriate amounts of material were weighed into preweighed porcelain crucibles and muffled at approximately 600°C for two hours. They were then cooled, reweighed, ground to powder, and 50 to 100 mg. portions were transferred to preweighed counting dishes. The sample was then spread, wetted down, redried, and reweighed before counting for alpha and beta activity.

(1) Fish Samples

The assaying procedure was as follows:

(a) Flesh. Ten grams finely chopped were weighed into a preweighed porcelain crucible.

(b) Bone. Approximately one gram of scraped dense bone was weighed into a preweighed porcelain crucible.

(c) Scales. Approximately five tenth gram was weighed into a preweighed porcelain crucible.

(d) Viscera. The entire stomach and intestinal contents were weighed into a preweighed porcelain crucible.

(2) Algal Samples

The samples were blotted dry with absorbent paper and approximately ten grams were weighed into a porcelain crucible.

RADIOACTIVITY OF MUD

Mud samples were dried over night at 110°C in an oven. They were then pulverized and sieved. One gram of dried sieved mud was then weighed into an aluminum planchet and rewet with water and redried. They were then counted for alpha and beta activity.

COUNTING PROCEDURE

All activities are reported as micromicrocuries per liter of water or micromicrocuries per gram of other material. The error is reported in the same units as the activity and is determined at the 90% confidence level.

(1) Alpha Activity

All samples were counted for alpha activity for 30 minutes in either an internal proportional counter or a scintillation counter, using a zinc sulfide phosphor and an RCA 5819 photomultiplier tube. Self absorption corrections were made on the water samples. A Pu^{239} alpha source was used as a standard.

(2) Beta Activity

All samples were counted for beta activity for 30 minutes in either an internal proportional counter or a shielded thin end

window GM counter, using a conventional tube-and-sample mount. A Radium D and E NBS standardized source was used as a standard, with the alpha shielded out in the internal proportional counter.